STAFF REPORT

PIER
Public Interest Energy Research
CALIFORNIA ENERGY COMMISSION

Energy-Related
Environmental Research

PIER ENVIRONMENTAL AREA RESEARCH PLAN: ENVIRONMENTAL CONTEXT AND KEY ENVIRONMENTAL ISSUES

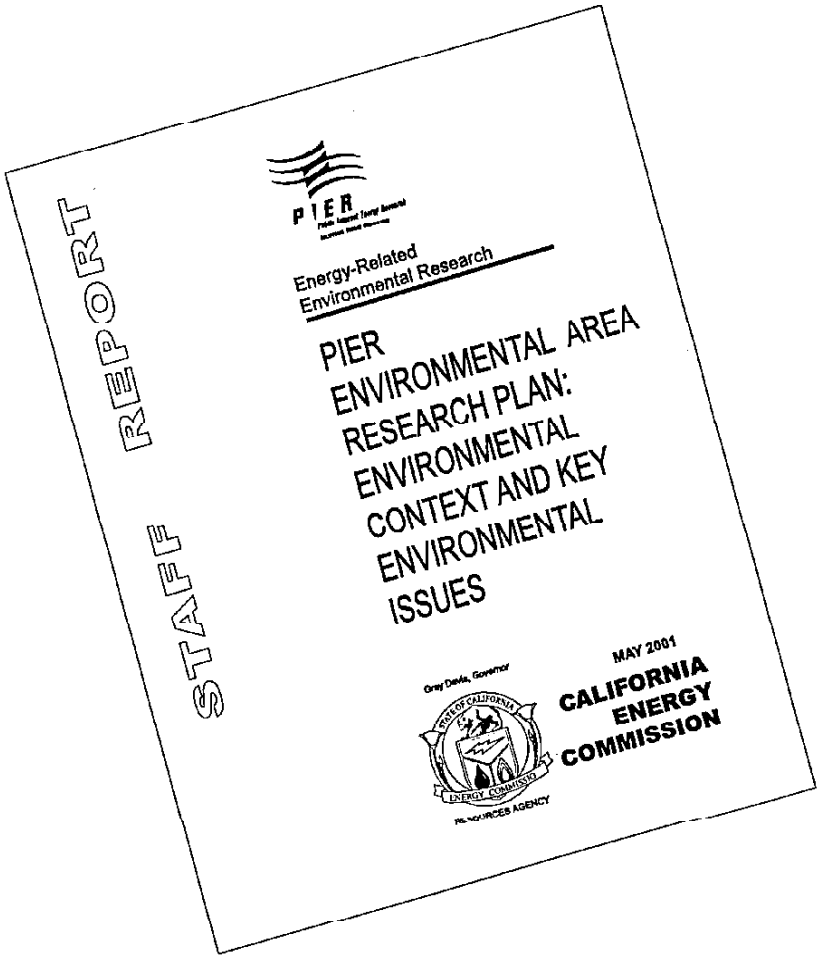
Gray Davis, *Governor*

MAY 2001

CALIFORNIA ENERGY COMMISSION

RESOURCES AGENCY

P600-01-014



CALIFORNIA ENERGY COMMISSION

Prepared for:
CALIFORNIA ENERGY COMMISSION

Prepared by:
PIER Environmental Area Staff

in Collaboration with the

University of California

Sacramento, CA

Contract No. 700-99-019

Gina Barkalow, *Contract Manager*
ENERGY-RELATED ENVIRONMENTAL RESEARCH

Kelly Birkinshaw, *Team Lead*
ENERGY-RELATED ENVIRONMENTAL RESEARCH

Legal Notice

This report was prepared as a result of work sponsored by the California Energy Commission (Commission). It does not necessarily represent the views of the Commission, its employees, or the State of California. The Commission, the State of California, its employees, contractors, and subcontractors make no warranty, express or implied, and assume no legal liability for the information in this report; nor does any party represent that the use of this information will not infringe upon privately owned rights. This report has not been approved or disapproved by the Commission nor has the Commission passed upon the accuracy or adequacy of this information in this report.

Acknowledgements

We are appreciative of the contribution of many individuals to the planning, development, production, and review of this report. We specifically wish to acknowledge the contribution of the following individuals and their affiliations:

California Energy Commission

- Kelly Birkinshaw, PIEREA Program Manager
- Gina Barkalow
- Guido Franco
- Matt Layton
- Joe O'Hagan
- Linda Spiegel

University of California/California Institute for Energy Efficiency

- Jim Cole
- Ed Vine

University of California at Davis

- Stephanie Peck
- Jim Quinn

University of California at Riverside

- Jim Lents

Consultants

- Jan Sharpless
- Mark Wilson

Table of Contents

Section **Page**

List of Figures

Figure **Page**

Table

Table **Page**

Preface

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program, managed by the California Energy Commission (Commission), annually awards up to $62 million through the Year 2012 to conduct the most promising public interest energy research by partnering with Research, Development, and Demonstration (RD&D) organizations, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following six RD&D program areas:

- Buildings End-Use Energy Efficiency
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy
- Environmentally Preferred Advanced Generation
- Energy-Related Environmental Research
- Strategic Energy Research.

In 1998, the Commission awarded approximately $17 million to 39 separate transition RD&D projects covering PIER subject areas. These projects were selected to preserve the benefits of the most promising ongoing public interest RD&D efforts conducted by investor-owned utilities prior to the onset of electricity restructuring. Since then funding for research in all PIER program areas has continued through various funding mechanisms. In order to take a longer term view of issues and their priority for funding, the Energy Related Environmental Research Area is conducting an intensive planning effort. What follows is the Research Plan for the Public Interest Energy Research Environmental Area (PIEREA).

For more information on the PIER Program, please visit the Commission's Web site at: http://www.energy.ca.gov/research/index.html or contact the Commission Publications Unit at 916-654-5200.

Executive Summary

In 1996, California adopted legislation that drastically revamped operation of this State's investor-owned electric services industry. The legislation also authorized collection of a surcharge on retail electricity sales to ensure a continuation of public interest energy research, development, and demonstration projects. Energy-related environmental research is one of six[1] subject areas identified for funding in the enabling legislation.

As an element of a larger effort, the California Energy Commission is preparing a Research Plan for the Public Interest Energy Research Environmental Area (PIEREA). The Research Plan will be a long-term plan (of at least five years) that will be used for targeting research projects through the PIEREA. These projects will focus on the environmental issues associated with the generation, transmission, distribution, and use of electricity in the State. Four subject areas have been identified for preliminary investigation: (1) aquatic resources; (2) land use and habitat; (3) outdoor air quality; and (4) global climate change. The plan is expected to be updated biannually.

This report represents the first major deliverable in the ultimate development of a programmatic research plan. It provides information on how the generation, transmission, distribution, and use of electricity in the State are affected by market, technological, demographic, and regulatory drivers and trends. Each of these drivers and trends affects the State's environment and influences which environmental issues the State must address. The PIEREA team identified crosscutting drivers and trends: (1) growing economy, (2) increasing population, (3) increasing electricity consumption and demand, (4) increasing public concern about the environment, (5) electric power industry restructuring, (6) strong environmental policies, rules, and regulations, and (7) the promotion of new technologies. The PIEREA team also identified more specific drivers and trends affecting the subject areas of concern (aquatic resources, land use and habitat, outdoor air quality, and global climate change).

The PIEREA team examined potential environmental issues on the basis of multiple criteria (e.g., degree of urgency for resolving the issue, statewide significance of the issue, and potential for cost sharing). As a result, 11 high-priority environmental issues were selected for Fiscal Year 2001 research project targets. Issue statements for these 11 high-priority issues are listed below.

Aquatic Resources

- Electric power plants that use water for power production or cooling alter or eliminate natural ecological and hydrological functions in aquatic systems. These facilities affect riverine, estuarine, and marine systems, and they have contributed significantly to aquatic species decline. Adverse impacts include

[1] Legislatively, there were five subject areas: Renewable Energy Technologies; Environmentally Preferred Advanced Generation; Energy-Related Environmental Enhancements; End-use Energy Efficiency; and Strategic Energy Research. Administratively, the Energy Commission has split End-use Energy Efficiency into two subject areas: Industrial/Agricultural/Water and Buildings.

fatality from impingement (i.e., trapping aquatic organisms against intake screens) and entrainment (i.e., passing aquatic organisms through cooling systems and pumping intake valves and turbines); blockage of fish movement and migration; fragmentation of ecosystems; and alterations in normal stream flows and temperatures. Hydroelectric power plants that use water for energy production can impact aquatic resources through alteration of upstream and downstream habitat as well as entrainment and impingement. Thermal power plants that use water for cooling can impact aquatic resources not only by impingement and entrainment at intake structures, but also may alter temperature and water quality around discharge structures.

- The cumulative impacts of multiple hydroelectric facilities on aquatic resources and terrestrial habitats in a watershed are difficult to evaluate, because of a lack of site-specific information and appropriate methodologies.
- Both electric power industry restructuring and the relicensing of hydropower projects are expected to affect the environmental management and stewardship of land and water resources by owners—including the potential for changes in peak power production and a shift in resource priorities. Although divestiture of investor owned utility hydropower systems has been delayed by legislation, there is a need to better identify and understand these impacts.

Land Use and Habitat

- Wildlife and avian interactions with utility structures can result in electrocutions on poles used for distribution lines and collisions with transmission line conductors or wind turbines and supporting guy wires. Such interactions can result in negative impacts to birds, costly power outages, and violations of State and federal laws. Transmission line systems can cumulatively contribute to habitat loss and degradation, the primary factors leading to species endangerment and decreased biodiversity.

Outdoor Air Quality

- There is a need for improved methods, tools, and data to estimate impacts of emerging energy technologies (e.g., distributed energy) and fuels on air quality.
- There is a need for improved methods, tools, and data to quantify the air quality impacts of energy-efficiency and load management measures for preparing air quality management plan baselines and as offsets or emission reduction credits.
- Electricity generators and the development of transmission and distribution infrastructure can increase local air emission impacts and place a disproportional burden of those impacts on local minority and low-income communities.

Global Climate Change

- There is a need for improved methods and tools to translate global circulation modeling results to California regional climate, so that researchers can analyze the impacts of global climate change in California and an evolving electricity system in particular.

- There is a need for improved methods, tools, and data to: (1) develop simple and accurate guidelines to estimate the greenhouse gas (GHG) emissions reductions in power plants that are attributable to the implementation of electricity conservation efforts; (2) prepare comprehensive inventories of GHG emissions (e.g., CO_2 emissions and their sources, methane emissions from the operation of hydropower facilities and other sources, N_2O emissions and their sources, and other GHG emissions and their sources); and (3) develop supply curves of GHG emissions-reduction options.

Crosscutting

- When addressing the environmental impacts related to the generation, transmission, distribution, and use of electricity, concerns about aquatic resources, land use and habitat, air quality, and global climate change are intimately related. A whole systems approach is needed for understanding the interaction of all parts of the system, including growth, economic development, and new technologies; the influence of regulatory requirements; and how the impacts, benefits, and tradeoffs of different scenarios affect energy development and impact the environment. For example, it is not clear how future air quality management plans will contribute to efforts to reduce pollutants or if an integrated approach would reduce the total cost to the State economy. Therefore, there is a need to coordinate and integrate programs and regulations that address aquatic resources, land use and habitat, air quality, and global climate change to avoid future penalties to the State economy from costly, uncoordinated efforts.[2]*****
- There is a need for improved methods, tools, and data to estimate the benefits and impacts of emerging technologies (e.g., renewable energy) on ecosystems and air quality.*****

In addition to these high-priority issues, 19 issues listed in Appendix B were considered in the initial review process. While important, these issues were given lower priority, and therefore will not be the subject of considerable further review during 2001. Reasons for this decision are: (1) research projects at the Energy Commission are currently addressing the issue; (2) the issue is not well understood; (3) the issues is not considered to be of great urgency in California at this time; or (4) other agencies are already targeting significant resources to resolving the issue. For many issues determined to be not well understood, a scoping study will be initiated to help better identify the problem. The identification and selection of additional issues (including reconsideration of the issues listed in Appendix B) will be the subject of a biannual planning effort conducted for PIEREA.

The PIEREA team sought the advice of stakeholders and technical reviewers on the merits of these issues through review of an earlier draft of this document. As a result, 66

[2] Nine environmental issues are areas targeted for funding full-scale research projects. The two environmental issues denoted with an asterisk (*) require preliminary scoping studies to determine whether full-scale research projects should be initiated.

stakeholders and technical reviewers provided comments and recommendations, which were considered in preparing this final document. The Commission will now initiate additional planning to define the goals, milestones, and strategies for addressing the high-priority issues in the form of comprehensive research plans, or roadmaps. This process will involve the creation of Planning Teams composed of individuals with specific expertise relative to the selected issues. The Planning Teams will conduct a minimum of one workshop with the research community, regulators, and key stakeholders to discuss the key issues and projects to be developed.

1.0 Introduction

1.1 *Description of the Public Interest Energy Research Environmental Area*

In 1996, California adopted legislation that drastically revamped how this State's investor-owned electric services industry operates (1996 Statutes, Chapter 854, hereinafter AB 1890). The legislation also authorized collection of a surcharge on retail electricity sales of not less than $62.5 million annually for four years, to ensure a continuation of public interest energy research, development, and demonstration (RD&D) projects. Because of the source of funding, the Public Interest Energy Research (PIER) Program is specifically mandated to produce public interest benefits for electricity ratepayers in California.

The PIER program was established at the California Energy Commission (the Energy Commission) to implement the RD&D provision of AB 1890, funded at $61.8 million annually from January 1, 1998 to December 31, 2001. Senate Bill 90 further defined the PIER program in October 1997, identifying key program areas and administrative and funding criteria. In September 2000, the governor signed legislation (AB 995) that continues PIER program funding for another 10 years (through January 1, 2012).

The Energy Commission has established six major subject areas for the PIER Program. These subject areas include: Residential and Commercial Buildings End-Use Energy Efficiency; Industrial / Agricultural / Water End-Use Energy Efficiency (Process Energy); Renewable Energy Technologies; Environmentally Preferred Advanced Generation; Strategic Energy Research; and Energy-Related Environmental Research.[3]

As one of the six major subject areas, Energy-Related Environmental Research (otherwise called the *PIER Environmental Area,* or *PIEREA*) is responsible for addressing the environmental impacts and beneficial uses of electricity in California. As defined by the PIER strategic plan (California Energy Commission [CEC] 1997), the overall mission of the PIEREA is to:

> "Develop cost-effective approaches to evaluating and resolving environmental effects of energy production, delivery, and use in California, and explore how new energy applications and products can solve environmental problems."

Protecting and improving the environment is a major element of planning in each of the six subject areas. The mission of PIER is to conduct energy research to improve quality of life by "…providing *environmentally sound*, safe, reliable and affordable energy services and products…" [emphasis added]. The research conducted in the PIEREA is therefore crosscutting. In addition to addressing suspected and documented environmental impacts of electricity, PIEREA provides basic scientific information and

[3] More information about the mission, goals and objectives, and funded research of the PIER Program can be found at www.energy.ca.gov / research / PIER / index.html.

tools for understanding the environmental implications of related technology and fuel choices that may be undertaken elsewhere in the PIER Program.

1.2 *Planning Process*

This PIEREA Research Plan is being developed to provide a long-term (at least five-year) plan that targets energy-related environmental research projects for PIER program four funding in subject areas:

1. Aquatic resources
2. Land use and habitat
3. Outdoor air quality
4. Global climate change

The major goal of this effort is to identify, develop, evaluate, refine, and select RD&D initiatives that address major energy-related environmental issues for California, to be funded through the PIEREA. This Plan provides a broad framework and justification for selected RD&D initiatives based on: (1) planning criteria used to assess the relative importance of environmental issues; (2) a RD&D program planning-level methodology for assessing benefits, costs, and other impacts across subject areas as part of a process of developing an integrated Plan; and (3) an overall RD&D program-planning rationale for discriminating between potential high-priority and low-priority RD&D initiatives. The Plan addresses ways of improving scientific understanding of the adverse public health and environmental impacts attributable to the generation, transmission and distribution, and use of electricity, as well as ways of developing mitigation / enhancement strategies, tools, or technologies to address these adverse impacts.

Figure 1 outlines the long-term PIEREA Environmental Planning Process.

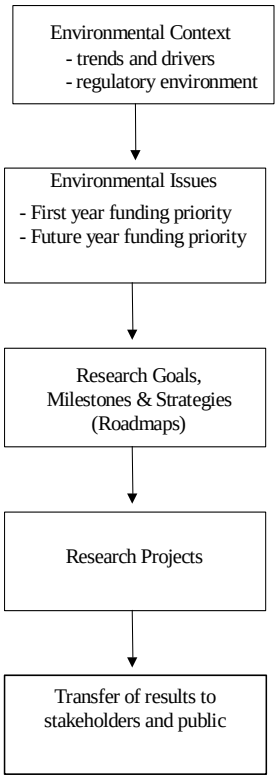


Figure 1. PIEREA Environmental Planning Process

This report constitutes the first two steps outlined in Figure 1. To develop this Plan, the PIEREA team collected and analyzed the following type of information:

1. The major trends and drivers affecting electricity and the environment in California
2. Key current and future issues and rationale for possible inclusion in PIEREA
3. Existing environmental research efforts relative to identified key electricity-related issues, conducted by the Commission and other organizations
4. Major gaps in environmental research relative to issues

Through this process, 30 environmental issues were first identified. Using a list of evaluation criteria (Appendix C), the team developed a shorter list of high-priority environmental issues for near-term attention. The team used a modified Delphi method for analyzing the issues and making issue selections for consideration by the Commission. The evaluation criteria formed the basis for discussions and ultimate selections by the team—during which a consensus rationale was defined and is presented in Section 3.2. In addition to these high-priority issues, 19 issues listed in

Appendix B were identified and evaluated in the initial review process. Although important, these were given lower priority, and therefore will not be the subject of considerable further review during 2001. Reasons for this decision are either: (1) research projects at the Commission are currently addressing the issue; (2) the issue is not well understood; (3) the issue is not considered to be of great urgency in California at this time; or (4) other agencies are already targeting significant resources to resolving the issue. For many issues determined to be not well understood, a scoping study will be initiated to help better identify the problem. The identification and selection of additional issues (including reconsideration of the issues listed in Appendix B) will be the subject of a biannual planning effort conducted for PIEREA.

For the 11 high-priority issues identified in this report, more specific research plans or roadmaps will be developed by Planning Teams with specific expertise relative to the selected issues that include long-, mid-, and short-term goals, milestones, and strategies for addressing the issues. The research actually funded will be selected from proposals received by PIEREA, and will include both short- and long-term research activities.

The Plan is intended to be a living document and will be updated to remain current with end-user needs, with the state of the science in the subject areas being addressed, and with pending legislative or regulatory decisions. The Plan is a portfolio of environmental research issues of both short-term and long-term relevance. Similarly, research activities addressing these issues will include a mix of efforts having short-term and long-term durations. This Plan also conforms to the Commission's *Five-Year Investment Plan* for the PIER Program (CEC 2001a) and its long-term strategic outlook, the *California Energy Outlook Report,* which is currently being prepared.

The PIEREA team sought the advice of several stakeholders on the merits of the identified issues through review of an earlier draft of this document. As a result, 66 stakeholders and technical reviewers provided comments and recommendations, which were considered in preparing this final document (see Appendix D and E). Throughout the Plan's implementation, stakeholder involvement will remain crucial to ensure that the proposed research is relevant and that results are communicated effectively. Stakeholder participation will increase the credibility of the planning effort and will promote understanding of and interest in the planning process findings.

1.3 *Relationship with Other PIER Efforts*

Another aim of the Plan is to address environmental issues raised by research and development efforts of the other PIER areas. Certain of these issues, such as those associated with renewable energy (e.g., avian collisions with wind turbines) are addressed within this plan. Other issues raised by other PIER area activities will have to await further development of these programs and, therefore, will have to be addressed in later versions of this Plan. There will be close coordination and collaboration with the other PIER areas in developing solutions to the environmental issues addressed in this Plan.

1.4 *Areas Not Addressed by PIEREA*

There are certain research areas that PIEREA is not addressing. First, the PIEREA Program does not support the design of educational curricula, the training of teachers, or other traditional educational activities. However, the transfer of research results is a critical activity in PIEREA, and PIEREA will communicate its research findings to decision-makers, the public, stakeholders, and potential users of the results. In addition, a PIEREA goal is to involve stakeholders early in the planning process, as well as in the implementation of its research activities, to ensure early buy-in and effective transfer of research products.

Second, this Plan is not intended to be a catalogue of environmental impacts from the generation, transmission and distribution and use of electricity. As required by law (Senate Bill 110; 1999 Statutes, Chapter 581), the Commission has prepared a report on the environmental performance of electric generation facilities. As stated in this legislation, the plan will contain an "assessment of the geographic distribution of statewide environmental, efficiency, and socioeconomic benefits and drawbacks of existing generation facilities, including, but not limited to, the impacts on natural resources including wildlife habitat, air quality, and water resources, and the relationship to demographic factors." This report (July 2001) includes "…how expected or recent resource additions could change the assessment through displacement or reduced operation of existing facilities."

Third, this Plan is not intended to be a statewide energy plan. Historically, the Commission has prepared statewide energy plans and is in the process of producing another plan in 2001: the *California Energy Outlook Report.* Because of recent energy events in California, the publication of this report has been delayed. Once it has been published, the PIEREA team will review the report to see what environmental research issues need to be addressed.

Fourth, this Plan does not directly address public health and safety research issues. The Plan does support research on precursors of health impacts (e.g., air quality emissions), but health studies are expected to be conducted outside of the Commission by other agencies with direct legal responsibility (e.g., California Air Resources Board, or the California Department of Health Services). Another PIER program (Residential and Commercial Buildings Program) is currently developing a research plan on indoor environmental quality issues.

Fifth, electricity, not fuels, is covered by the PIER program. Hence, this Plan does not address transportation issues or fuels. The Commission has a Transportation Technology and Fuels Office that deals with all transportation research issues.

Lastly, this Plan does not support research on the development of generation or energy efficiency technologies. This technology development is addressed through the Residential and Commercial Buildings Program, Industrial/Agricultural/Water Program, Renewables Program, and Environmentally Preferred Advanced Generation Program.

1.5 *Report Organization*

Section 2.0 focuses on how the generation, transmission, distribution, and use of electricity in California are affected by market, technological, demographic, and regulatory drivers and trends. Section 3.0 identifies and discusses the environmental issues that will be the focus of research funding in the coming years. Section 4.0 provides a discussion of the follow-on steps required to continue this research. Section 5.0 contains a glossary and Section 6.0 provides a list of references. The report also contains five appendices:

Appendix A	PIEREA Projects
Appendix B	Environmental Issues
Appendix C	Evaluation Criteria
Appendix D	Stakeholder Review Group
Appendix E	Highlights of the Review of the Draft CEC Staff Report

2.0 California Context

2.1 *Overview*

This section focuses on how the generation, transmission, distribution, and use of electricity in the State are affected by market, technological, demographic, and regulatory *drivers* and *trends*. Each of these drivers and trends affects the State's environment and the State's energy system and determines which environmental issues the State must address. (Section 3.0 addresses specific environmental issues.) This section first provides a broad overview of the drivers and trends in California that may affect the natural environment, and then focuses on distinctive drivers and trends in the following environmental subject areas: aquatic resources; land use and habitat; outdoor air quality; and global climate change. Each section examines how the State's energy system is affecting the environment.

California is the tenth largest energy consumer in the world, ranking slightly ahead of Italy and slightly behind France (CEC 2000a). The commercial sector consumes the largest percent of electricity in California, followed by the residential, industrial, agricultural, and other sectors (Figure 2) (CEC 2000b).

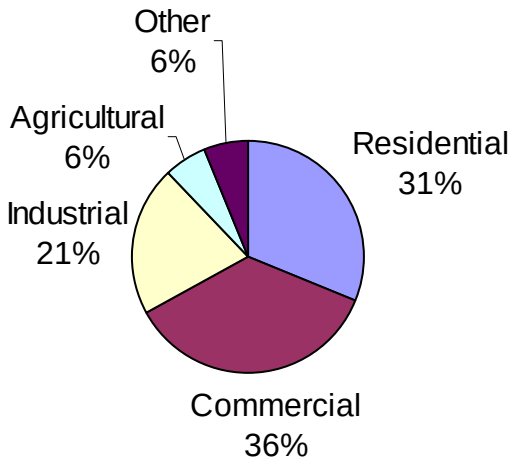


Figure 2. California Electricity Consumption by Sector, 1999 [Source: CEC 2000b]

The two largest sources of California's electricity come from gas and hydroelectricity, followed by coal (mainly from outside California), nuclear, renewables (including wind, solar, and biomass), and geothermal (CEC 2000c). Figure 3 shows the estimated generation sources, including imported power.

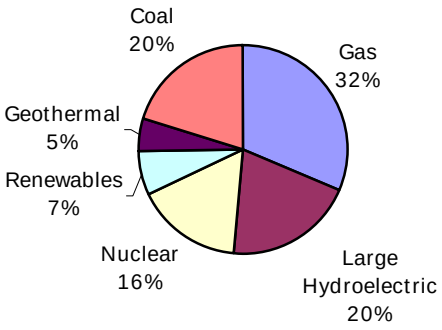


Figure 3. Electricity Sources in California, 1999 [Source: CEC 2000c]

Three-quarters of the State's electricity comes from in-state sources, and the Northwest and Southwest regions of the United States contribute almost evenly to the remaining 25 percent. About 1,000 California power plants generate 55,500 MW of capacity, and the State imports an additional 8,000 MW. Although there are more than 500 non-hydro power plants within the State, the majority of electricity from this source—more than 60 percent—is generated by only a small number of power plants (approximately 30). The State's transmission and distribution system, which connects California's electric utilities to the power grid, consists of about 50,000 miles of power lines.

2.2 *Drivers and Trends*

A driver is an activity that influences many people and geographical areas. Drivers may lead to trends. Examples of drivers include new environmental legislation, new regulatory agencies, and new distributed generation technologies. A trend indicates an activity that has been occurring or is expected to occur over several years. A trend can be increasing, decreasing, or curvilinear (increasing and decreasing over time). Examples of trends include increasing population, increasing per capita wealth, increasing economic development, increasing GHG emissions, and decreasing household size.

It is often difficult to separate drivers and trends; therefore, drivers and trends are considered together. For the purposes at hand, the impacts of drivers and trends on the environment and resulting environmental issues are the crucial elements for the planning process described in this report. The following sections discuss drivers and trends that crosscut all subject areas of concern and then provide those specific to each subject area of (1) aquatic resources, land uses, and habitat; (2) outdoor air quality, and; (3) global climate change.

2.2.1 Crosscutting Drivers and Trends

Many crosscutting drivers and trends affect the generation, transmission, distribution, and use of electricity in California. As a result of these drivers and trends, new generation facilities will need to be built in the near future to meet an increased energy demand, and these facilities will need to be licensed and sited. The following subsections discuss the crosscutting drivers and trends that affect the development of new California power plants.

2.2.2 Growing Economy

In 1996, only six countries had economies larger than that of California (Legislative Analyst's Office 1998). California's economy experienced a recession in the early 1990s, in which the State lost more than 720,000 jobs. The economy has picked up momentum in recent years (especially in Northern California), led by such diverse sectors as international trade, movie production, tourism, and high-technology manufacturing and services. This growth has led to an increased demand for energy in the residential, commercial, industrial, and agricultural sectors, which will require new generation facilities.

2.2.3 Increasing Population

The State's population growth rate has been steadily increasing (but with varying rates) since the 1920s. Since 1990, it has increased at a rate of 1.4 percent per year (California Department of Finance 2000; Lopez 1999). California's population is expected to reach approximately 50 million people in the next 20 years (California Department of Finance 2000), and much of this growth is expected to occur in the State's hot inland valleys. This growth will lead to more housing and greater energy and related infrastructure demands in providing the services needed for a growing population.

2.2.4 Increasing Electricity Consumption and Demand

From 1980 to 1990, total statewide electricity consumption grew at an annual growth rate of 3.2 percent (CEC 2000a). Consumption growth slowed in the early 1990s as a result of the severe economic recession; per capita energy consumption slightly decreased in the 1990s (about 235 million Btu / capita in 1997). With the predicted future increases in economic and population growth, electricity consumption is expected to grow at a rate of approximately two percent / year for the 2000–2010 time frame. The statewide peak demand is expected to grow at a rate of 1.7 percent / year during that same period. New generation facilities will be needed to meet this energy demand.

2.2.5 Increasing Public Concern about the Environment

The American public is very sensitive to environmental and public health issues, including deteriorating air and water quality, unsafe conditions, loud noise, visual blight, electromagnetic radiation, habitat loss and degradation, and decreasing biodiversity (The Gallup Organization 2000). Specific issues of concern are pollution of drinking water, rivers, lakes, and reservoirs; toxic contamination of soil and water; air pollution; and global warming (The Gallup Organization 2000). The public's concern for clean air and water will

continue to affect the future of energy use in the State, e.g., favoring the introduction of clean energy technologies such as energy efficiency and renewable energy technologies, particularly since California households have expressed strong beliefs in protecting the environment over the years (based on California survey data). For example, more than 128,000 California households (equivalent to approximately 350,000 people) were served Green-e certified electricity in 1999 (Center for Resource Solutions [CRS] 2000).[4] More important, 80 percent of the accounts that made an active decision to switch electricity service providers switched to a Green-e certified product.

2.2.6 Electric Power Industry Restructuring

Restructuring of the energy industry is a crosscutting issue because it affects all the subject areas described in this report. However, because it has specific effects in each of these areas, it is also addressed in greater detail in each of the subject area sections.

Assembly Bill 1890, passed by the California legislature in August 1996 and signed by Governor Pete Wilson shortly thereafter, initiated electric industry restructuring in the State. Although AB 1890 preserves California's commitment to developing diverse, environmentally sensitive electricity resources, the net effects of restructuring depend on many factors: underlying fuel markets, existing capacity mix, the type of regulatory changes accompanying restructuring (e.g., a renewable portfolio standard, production tax incentives for renewables, a public benefit charge, and removal of regulatory barriers to combined heat and power and distributed power), demand responses to price changes, and load shifting. The mechanics of restructuring, and the potential changes in environmental regulations and effects are uncertain, requiring ongoing research (Regulatory Assistance Project 1999).

Since the summer of 2000, California utilities have experienced high prices for electricity on the wholesale market and supply problems that caused electricity outages and rolling blackouts in California (California Public Utilities Commission [CPUC] 2000). In addition, natural gas prices have soared. As a result, ratepayers have been confronted with energy bills much higher than those from previous years. Also, industries particularly sensitive to a reliable supply of power (e.g., telecommunications, biotechnology, and semiconductor manufacturers) are starting to develop their own energy sources to ensure adequate electricity reliability. These serious examples may represent a precursor of what lies ahead for California's economy in the short-term.

In August 2000, the California Legislature passed a number of bills to address these electricity system issues. For example, AB 970 recognizes that, as a result of the increased demand for electricity, a serious lag in the construction and operation of new generation facilities, and insufficient energy-efficiency measures, California may face serious electricity shortages over the next two years. Under AB 970, the Energy Commission is able to certify certain electrical generation facilities through an expedited

---

[4] Electricity that is certified by the Green-e Program must meet the environmental and consumer protection standards established through the Green-e advisory process by the nonprofit Center for Resource Solutions. Electricity service providers who sell certified electricity undergo an annual independent process audit to verify that they meet Green-e standards (CRS 2000).

review and approval process if they satisfy specific conditions that ensure that the facility will not pose significant adverse effects on the environment as a result of construction or operation.

However, measures such as this may be insufficient for providing the electricity necessary to supply California's needs, and a continued electricity shortfall has created pressure to relax environmental standards as a means to increase the supply of electricity. Executive Orders signed by the governor in early January 2001 ordered the California Energy Commission to expedite the processing of applications for certification for existing thermal power plants that require retooling and a current license to operate (D-22-01); ordered the State Water Resources Control Board (SWRCB) to ensure power plants are not precluded from operating as a result of thermal limits in waste discharge requirements (D-22-01); and ordered all State and local agencies to shorten the review periods to seven days for environmental documents prepared under the California Environmental Quality Act for all power plants that are proposed to be on-line by the summer of 2001.

2.2.7 Strong Environmental Policies, Rules, and Regulations

California has an environmental regulatory infrastructure (consisting of local, regional, State, and federal agencies) that promulgates environmental policies, rules, and regulations that address the electricity-related environmental issues confronting California. These rules and regulations ensure that issues are identified and appropriate environmental mitigation is applied to protect the health and welfare of the citizens of California. If environmental impacts deemed significant could not be avoided, mitigation measures must be identified and implemented to offset the impact and contribute to recovery. Although these rules and regulations are recognized as among the most stringent in the Nation, there is broad consensus that they are not a major contributor to the current energy crisis in California (King 2001; Leavenworth and Bowman 2001; Natural Resources Defense Council 2001).

Key legislation affecting the California environment includes: California Environmental Quality Act (CEQA), California and federal Endangered Species Acts, California and federal Clean Air Acts, federal Clean Water Act, Kyoto Protocol, National Ambient Air Quality Standards, and regulations affecting ozone, PM_{10}, and $PM_{2.5}$. The State's power plant permitting process, as defined under the Warren-Alquist Act, is CEQA-equivalent (i.e., the analysis required by the Energy Commission's regulations produces a document that is, in practice, a CEQA analysis) and requires new thermal energy projects greater than 50 megawatts to comply with federal, State, and local laws, regulations, ordinances, and standards. For those energy facilities not under the Energy Commission's jurisdiction, the lead regulatory agency must still ensure CEQA requirements are met. For hydroelectric facilities and energy facilities located on federal lands, primary permitting authority resides with the appropriate federal agency.

2.2.8 Promotion of New Technologies

Technology development and dissemination is a dynamic field that affects both the supply and use of energy. Recent central generation station technology of choice has

been natural-gas-fueled, combined-cycle turbines. Use of advanced exhaust gas clean up and cleaner, more efficient systems have led to significant, steady emission reductions per energy generated when compared to older, fossil-fired boilers. Renewable energy technologies and, in particular, distributed energy resources (DER) such as solar cells, microturbines, and fuel cells are being promoted by State and federal governments (Dunn 2000). On the demand-side, the introduction and commercialization of new energy-efficiency technologies and services (including some electrotechnologies) are improving the energy efficiency of the residential, commercial, industrial, and agricultural sectors. New development of wind, geothermal, and small hydroelectric generation sources is also likely in the coming decade. Other technologies (e.g., fuel cells) are still in the early stages of commercialization. Prior to committing substantial resources, it is important to evaluate not only the increased output from existing technologies, but also the changing character and location of emerging generation technologies, in an effort to prevent, rather than mitigate, unintended environmental consequences.

2.3 *Aquatic Resources, Land Use, and Habitat*

This section describes those drivers and trends most relevant to the aquatic resources and land use and habitat impacts of electric power generation, transmission, distribution, and use. Aquatic resources include those trends and drivers that affect water supply, water quality, and aquatic organisms. Because water and land resources are so closely interrelated, this section addresses both resources together. The first section focuses on the regulatory framework influencing these subject areas, followed by a discussion of specific trends and drivers affecting aquatic resources, land use, and habitat.

Issues associated with water use efficiencies, conservation, and demand management are not addressed in this plan. (For a discussion of these issues, see Gleick 1994). Further, the relationship between water-use efficiency improvements and energy-use efficiency improvements and water needs and water supply benefits of renewable technologies are not discussed because substantive research is ongoing in the Agricultural/Industry area of the PIER program.

2.3.1 The Regulatory Framework

As large industrial facilities, power plants have been a major focus of legislative efforts to improve environmental quality. Although regulations established to implement this legislation have historically been of the command and control form, increasingly, new and flexible risk-based or market-based regulatory approaches that account for site-specific conditions are being considered when establishing permitting conditions. These approaches will require new scientific information and analytical tools that are not currently available but are critical for achieving established environmental standards. The following subsections discuss the key laws and regulations that govern the management of water, aquatic and terrestrial resources, and land use.

2.3.1.1. Federal Legislation

The Endangered Species Act

Past economic development and population increases have resulted in habitat loss and degradation that has greatly contributed to a decline in California's natural biological diversity (Jones & Stokes 1987). Although there are exceptions, species extinction and habitat losses are occurring now at rates far greater than at any time in the past and will continue to do so with predicted future population and economic trends. The federal Endangered Species Act (ESA), administered by the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS), was enacted in 1973 to protect endangered and threatened plant and animal species and provide a means to conserve their ecosystems. New power plant facilities, or major changes in operations of many existing power generation facilities (particularly dams), are subject to review under the ESA. The ESA prohibits any *taking* (which includes causing mortality, harassment, or damage to critical habitat) of a listed species without a permit. Federally regulated activities, including most power generation and facility relicensing, must generally satisfy regulators such as the USFWS or NMFS that the proposed activity is consistent with *recovery* of listed populations.

An example of ESA actions pertinent to power generation are operational effects on aquatic species. Although there are exceptions, modifications to river systems from hydroelectric operations are viewed as a primary cause for decline in populations of Chinook salmon, coho salmon, and steelhead trout. Elsewhere in the United States, particularly in the Pacific Northwest, there is considerable pressure to remove hydroelectric power facilities (or greatly modify their operations), in order to achieve salmonid recovery goals under ESA. Cooling intakes for large fossil-fuel power plants may have detrimental effects on populations of other listed species in marine estuaries and the Sacramento River Delta.

The Migratory Bird Treaty Act and the Bald Eagle Protection Act

The Migratory Bird Treaty Act, originally enacted in 1918 and administered by the USFWS, protects migratory birds from *unlawful taking*—defined as wounding, killing, trapping, and capturing. The Bald Eagle Protection Act, also administered by the USFWS, was enacted in 1940 to protect the bald eagle and the golden eagle by prohibiting, except in specified conditions, their taking, possession, and commerce. In January 2001, an Executive Order was issued to further protect migratory birds by requiring federal agencies that take actions having a negative effect on these populations to develop and implement a Memorandum of Understanding (MOU) to promote their conservation (Executive Order 2001).

These laws have implications for the generation, transmission, distribution, and use of electricity. Migratory bird mortality by electrocution or collision with electric power distribution lines, and their deaths by collision with wind turbines (a particular problem at the Altamont Pass Wind Resource Area) can constitute a taking under these Acts. It has been estimated that approximately 750 raptors are killed each year by interaction with utility or electricity company facilities (personal communication from Dick Anderson, California Energy Commission, December 12, 2000).

Energy Policy Act of 1992

Clean Water Act

Point source and certain nonpoint source discharges of pollutants into the waters of the United States are regulated under the federal Clean Water Act (CWA). Until recently, implementation of the CWA focused on the control of point-source discharges. Currently, efforts are addressing the more pervasive problem of nonpoint source discharges. In addition, nationwide water quality assessments clearly show that nonpoint sources are the major source of water pollution (U.S. Environmental Protection Agency [EPA] 2000a). The Total Maximum Daily Load (TMDL) provisions of Section 303 of the CWA require that levels of pollutants protective of beneficial uses from both point and nonpoint sources be set for impaired water bodies. Relatively few TMDLs have been established so far in California, but most major water bodies are scheduled for assessment over the next five years (EPA 2000b). Of concern for electricity generation are temperature and sediment TMDLs that may affect hydroelectric facilities, and metal and temperature TMDLs that may affect water-cooled plants. Standardized scientific criteria and methodologies have not been developed for establishing TMDLs. Despite this, the development of TMDLs will be met upon using the best available information.

Sections 316 (a) and (b) of the CWA specifically address environmental impacts from power plants. Section 316 (a) addresses thermal cooling water discharges and Section 316 (b) deals with cooling water intake structures and the associated aquatic biota impacts of entrainment and impingement.[5] The EPA has recently released proposed 316 (b) regulations for new facilities; proposed regulations for existing facilities have been bifurcated and are expected to be released in 2002 and 2003 (EPA 2000c, 2000d). A majority of the State's power plants that use once-through technology were constructed 40–50 years ago, and their cooling water intake and discharge structure design does not reflect technological improvements developed over the past few decades. These older facilities provide a significant portion of in-state generation and will be subject to these new requirements, whether these facilities will be repowered or not. The estimated cost of meeting these requirements, whether for new or existing facilities, will be significant. There is also concern that the proposed regulations are vague, may not reflect conditions in California, and are based on limited scientific evidence. Finally, alternative water intake technologies will need to be evaluated for both existing and new facilities.

Section 401(a) of the CWA mandates that federal actions must comply with state water quality standards. It requires that in California a federal permit must be certified by the SWRCB or one of the nine Regional Water Quality Control Boards (RWQCB) to be in compliance with state standards.

Invasive Species Executive Order

Federal resource agencies are required by a February 1999 Executive Order (Executive Order 1999) to develop invasive species management strategies to include prevention, response and control, and monitoring programs, as well as restoration of native species

[5]In this case, *aquatic biota* refers to fish, invertebrates, amphibians, reptiles, and plants.

and habitat conditions in invaded ecosystems. The Executive Order created an Invasive Species Council charged with preparation of a National Invasive Species Management Plan. Invasive species are increasing, joining threatened and endangered species as an issue of concern to natural resources agencies. Invasive species have risen to prominence because they have been implicated in the majority of cases where native species have become endangered or extinct.

One of the most visible invasive species issues affecting power generation is aquatic (Nadol 1999; Cohen 1995). Approximately half of the species found in California rivers and lakes are now exotic. At least 230 invasive species have invaded the San Francisco Bay and Delta, where introductions have led to the regional loss of native species, contributed to the decline and extinction of freshwater fish and damaged marshes and habitat (Cohen 1995). A variety of introduced predators, many of them game fish, occupy hydropower facility reservoirs or congregate below dams, where they are thought to be a factor in the elimination of native fish and amphibians.

Another important issue is the invasion of exotic plants on terrestrial landscapes. The process of land conversion, in combination with increased air emissions, has transformed native ecosystems in a manner that favors the invasion of many exotic plant species. As a result, many native populations of terrestrial plant species are reduced or eliminated, resulting in subsequent declines in animal species dependent upon them. The vast network of transmission lines throughout the State, roughly 50,000 linear miles, requires extensive land conversion for construction and maintenance. When located in natural habitats, such land disturbance can promote conditions for exotic plant species. In areas with high ambient nitrogen levels, incremental additions of NO_X from power plant emissions can significantly alter ecosystems adapted to low-nitrogen levels, which can result in conditions that favor invasive species over endemic species.

Federal Relicensing of Hydropower Facilities

Hydropower accounts for a little more than one-fourth of California power plant in state installed capacity. The production of hydropower is in decline, largely because more water is being set aside by federal regulators for environmental protection as dam licenses are renewed. Because of the current energy crisis in California, however, near-term supply shortages may be mitigated by an increase in the use of hydropower. Most dams and other hydropower facilities operate on one or more long-term federal permits, many of which have recently expired or soon will. The Federal Energy Regulatory Commission (FERC) grants each project a 30 to 50-year federal license to operate and establish environmental conditions for its operation (FERC 2000a). Licenses for 28 hydroelectric projects in California are due to expire in the 10-year period from 2000–2010 (FERC 2000b)**.** When a hydro license comes up for renewal, FERC must give equal consideration to power production and fisheries, wildlife habitat, and recreation (Baker 1994, Friends of the River 1999). The FERC relicensing process also considers the appropriateness of dam removal. A new license may be denied if the environmental costs of a dam exceed the value of its power generation. FERC may also set new operating requirements to protect downstream resources. FERC undertook a comprehensive review of policies, procedures, and regulations for the licensing of

hydroelectric projects to determine how to reduce the costs and time of obtaining a license and FERC reported its findings to Congress in 2001.

Resource agencies that may participate in the FERC licensing process (depending on the nature and location of the project and resources affected) include a variety of state and federal agencies. The roles of the agencies are different and they may be involved either as a commenting or conditioning authority or in an advisory capacity.

2.3.1.2. State Legislation

California Environmental Quality Act

All new, in-state, non-hydro generation facilities under 50 MWs located on private or state land are subject to the requirements of the California Environmental Quality Act (CEQA); plants generating 50 MWs or more are subject to a CEQA equivalent process. In addition to direct and indirect impacts, CEQA requires the evaluation of the cumulative impacts of a project. The California Environmental Quality Act defines cumulative impacts as "two or more individual effects which, when considered together, are considerable or which compound or increase other environmental impacts." As an example, migratory (especially anadromous) fish may not be heavily affected by the presence of one dam, but would be cumulatively impacted by many dams on a single tributary or by the presence of several dams blocking passage to several tributaries. Similarly, a single source of thermal pollution and/or lost shade may not raise temperatures above tolerances for juvenile salmon, but multiple incidents may create an impassable lethal zone of raised temperatures. Presently, cumulative analyses are often weak or nonexistent. However, improved electronic access to CEQA documents, better Geographic Information Systems (GIS) and evaluation tools, and perhaps changing attitudes among State and federal land use authorities are likely to lead to more serious consideration of cumulative impacts.

California Fish and Game Code

The CDFG also has authority under the Fish and Game Code to regulate and require permits for any activities that might cause mortality of native wildlife (not just rare species). The Department also administers Fish and Game Code addressing invasive species at the state level.

California Endangered Species Act

The California Endangered Species Act (CESA) generally parallels the provisions of the federal ESA, although it is perceived as often less stringent than the federal ESA. CESA is administered by the CDFG and prohibits the taking of plant and animal species that are designated by the Fish and Game Commission as either threatened or endangered. The take prohibitions apply to State candidate species that have been petitioned for listing, unlike the federal ESA, which applies only to those species already listed. California lists 47 species of animals and 129 species of plants on the State Endangered Species List (CDFG 2001). Another 30 animals and 20 plants are listed as threatened.

Electric Power Industry Restructuring

As a result of California's 1996 restructuring legislation (AB 1890), investor-owned electric utilities sold many energy production assets and have bought power on the open market. In 2000, Pacific Gas and Electric Company (PG&E) proposed to auction off its hydroelectric system, which included 68 powerhouses, 174 dams, and 76 diversions within 17 watersheds and 99 reservoirs. It also included the associated water rights for those assets. In addition, the system included 102,000 acres of FERC-jurisdictional watershed lands and an additional 40,000 acres of non-jurisdictional watershed lands. Concerns with ongoing operations and the consequences of possible divestiture included degradation of water quality levels (e.g., sedimentation, temperature, and nutrients); conversion of wild lands to other land uses; operating the hydropower system to maximize peak-power production; and diminished investment in natural resource management, fisheries, in-stream flow studies, and recreation.[6] Divestiture of hydropower facilities has been delayed by legislation but is now an element of the bankruptcy restructuring proposed by Pacific Gas and Electric Company.

Divestiture of hydropower facilities under restructuring is likely to affect operations of most hydropower dams in California because the open market encourages owners/operators to run hydroelectric operations harder, or differently than they otherwise might in a regulated environment. There is a need for improved monitoring data, a clear scientific baseline from which to measure change, and knowledge about utility behavior on operations, maintenance, and environmental compliance. It is probable that the current energy/financial crisis in California may be producing cutbacks in monitoring, compliance, and maintenance work, but there is no evidence or data to determine such changes or the long-term impacts these changes may have on the environment. Increases in flow due to changed operation can affect such factors as water temperature and sedimentation. For many facilities, the value of water for urban or agricultural water supply often exceeds the value of its power generation, changing the volumes and timing of releases. At the same time, environmental concerns—as well as flood control considerations—affect releases (e.g., to maintain minimum summer flows and sufficiently low temperatures for salmon reproduction), either through regulation or by purchase of water for environmental accounts. All of these changes are likely to decrease generation capacity and the ability of power companies to use hydro facilities to meet demand peaks**.** Presumably however, operation of a more privatized system will require more efficient and transparent marketing of water, power, and associated environmental services.

[6] On January 18, 2001, Governor Gray Davis approved legislation (Assembly Bill 6) that prohibited the selling of electricity generation facilities (e.g., PG&E's hydro facilities) before January 1, 2006.

2.3.2 Impacts, Trends, and Future Implications for Electricity

2.3.2.1. Water Supply and Demand

Using traditional water planning approaches, California faces water demands that are anticipated to exceed supplies, with shortfalls increasing from an estimated 1.6 million acre feet in 1995 to 2.4 million acre feet in 2020 (California Department of Water Resources 1998). As the value of water for power generation continues to grow, electric utility companies will increasingly become competitors for water, even though their requirements for water are relatively small (e.g., compared to agriculture). Conflicts are anticipated, especially in dry years, and there is concern that inflexible commitments to electricity production could affect water supply. The use of dry cooling technologies and degraded water in power plants could ameliorate this situation.[7] Water supply varies greatly in California of the natural variation of the distribution of water resources within the State, contractual agreements for imported water, the availability of reclaimed water, and the ability to meet existing demands for water. Complicating the seasonal and regional nature of water supply and demand, management of surface and groundwater supplies in California is spread among a myriad of State, regional, and local entities serving municipal, industrial, and agricultural customers. California's water supply will be unable to meet tomorrow's demand unless more emphasis is given to improvements in water-use efficiency, conservation, recycling, and water transfers among different users throughout the State (SWRCB 1997).

Although water consumption for power generation in California was estimated to be approximately 0.3 percent of total statewide consumption (Yankee Scientific 1991), the timely permitting of new, or expansion of existing, power plants is already being challenged by water supply issues. Fresh water demands for recent combustion turbine combined-cycle power plant applications before the Energy Commission have ranged from a total of 2,000 to 7,000 acre-feet per year (afy), with an average of about 1.1 acre-feet per year per gigawatt-hour (GWh). This amount is about one-third, on a GWh basis, of what would be required for a similar sized boiler-only (e.g., a nuclear or coal) power plant.[8] Despite these reduced fresh water needs, power plants, as heavily capitalized industrial facilities, have opportunities to conserve fresh water supplies through the use of degraded water for cooling or dry-cooling technologies.

---

[7] *Degraded water* refers to surface or groundwater sources not suitable for most other uses because of natural or anthropogenic contamination. Degraded water includes reclaimed or recycled water.

[8] In the 1970s, the California utilities proposed several large generation projects. Most were sited inland, as ocean sites were not a likely option. These include the PG&E Fossil 1 and 2, a 1,600-MW boiler facility, using up to 3.55 afy/GWh and a 2,400-MW nuclear plant at Stanislaus using about 3.56 afy/GWh. Neither project was built. Modern combined cycles average 1.1 afy/GWh. With the broader use of reclaimed and alternative water sources, fresh water use by the generation sector may be only 10 percent of what was expected in the mid-1970s. Actual fresh water use will vary considerably, depending on the cycles of concentration in the cooling and the use of alternative water sources or cooling towers.

2.3.2.2. Water Quality

Water quality concerns associated with electricity generation, transmission, distribution, and use stem from several sources. Thermal plant discharge, water pollutant effects of atmospheric deposition, wastewater from cooling tower blowdown, and changes in water temperature and amount of dissolved oxygen resulting from hydroelectric operations are impacts of electricity production that can adversely affect water quality.

Water quality concerns are leading to increased attention on, as well as enforcement of, federal and State regulations regarding point and nonpoint source pollution (Copeland 1997). In regions with limited water supplies, power plants are faced with the competing demands of reducing fresh water consumption through either water conservation measures or the use of degraded water supplies, while at the same time meeting more stringent wastewater discharge standards. Over 500 water bodies in California have been identified as not meeting water quality standards for the designated beneficial uses. Therefore, the quality of wastewater discharges from power plants and other types of heavy industry may have to be improved if existing discharges contribute to the impairment of water quality. This reduction may be achieved for power plants, for example, through the use of fewer cooling cycles or by treating the water before discharge.

Water demand by power plants using cooling towers can be reduced by increasing the number of cycles that the water is run through the cooling tower. However, although additional cycles can significantly reduce a project's water demand, it also concentrates the inorganic constituents originally found in the source water. The higher the number of cycles, the greater the concentration and the greater the difficulty in meeting water quality standards. With ongoing efforts to adopt new water quality standards and implementation procedures, it will be difficult for new facilities to comply without additional treatment.

2.3.2.3. Aquatic Habitat and Biota

California's streams, rivers, estuaries, and marine waters are home to a tremendous diversity of fish, amphibians, aquatic plants, invertebrates, and microorganisms. Some freshwater habitats are relatively discontinuous, and many species do not easily disperse across the land and estuarine barriers that separate river drainages into discrete units. Factors that contribute to the decline of aquatic ecosystems and their native biota are pollution, introduction of non-native species, over-harvesting, water diversions, and physical modifications of habitat (Abramowitz 1996). In terms of changes in species composition and overall diversity, freshwater rivers and lakes are, in the aggregate, more heavily affected by human activities than any other habitat type in California (Abramovitz 1996; McAllister et al. 1997; Mount 1995).

Power plant operations can affect aquatic biota through entrainment and impingement, blockage of fish migration, flow alterations, temperature changes, diversions, interbasin transfers, and loss of spawning and rearing habitat. Additional impacts to river systems by the operation of hydropower plants include channel modification, effects on riparian and wetland habitats, and sediment loading (Mount 1995; McCully 1996). Upper

watershed management concerns raised by hydroelectric projects include flooding, impacts to terrestrial habitat and wildlife, and effects on water quality.

Concern about the cumulative impacts of multiple hydroelectric facilities along a river system and in upper watershed areas has intensified over the past 20 years in response to an increase in hydropower development in the early 1980s and subsequent federal and State regulations and court rulings. FERC is beginning to assess basin-wide impacts, rather than looking just at individual projects.

2.3.2.4. Transmission System

The network of transmission lines throughout the State, roughly 50,000 linear miles, contributes to habitat fragmentation, degradation, and incremental loss. Wildlife and avian interactions with transmission system structures can result in fatalities and interrupt power supplies. The severity of these problems increases with increased development of power delivery systems. Bird fatalities are caused by electrocution with distribution lines and collisions with transmission lines. Electrocution or collision fatalities may represent a small percentage of mortality for most species, but can significantly affect endangered and threatened species, such as the highly endangered California condor and the threatened sandhill crane.

Electric and magnetic fields (EMFs) surrounding electric power lines and wires are considered by some people to potentially pose risks to human health and the environment. Human health consequences from exposure to low-level EMF, such as those under high-voltage transmission lines, are still of concern and are being debated. A working group convened by the National Institute of Environmental Health Sciences (NIEHS 1999) classified EMF as a possible carcinogen, based on limited evidence linking EMF to childhood leukemia and chronic lymphocytic lymphoma in adults. For other health outcomes, the working group concluded that the evidence was inadequate to either support or rule out a causal relationship to environmental EMF exposure (NIEHS 1999).

The management of transmission and distribution line right-of-ways requires consideration of vegetation management and herbicide use to minimize fire risk and maintain access. However, practices such as the planting of non-native plant species, the application of herbicides, operation of equipment, and frequent clearing can affect native habitat and aquatic and terrestrial ecosystems. Often, the services and accessibility provided by right-of-ways override environmental concerns. It is likely that management of right-of-ways will receive more attention from wildlife and water quality authorities in the next few years.

2.4 *Outdoor Air Quality*[9]

Many drivers and trends affect outdoor air quality in California: population, the economy, the regulatory environment, meteorological conditions and climate change,

[9] *Outdoor air quality* is distinguished from *indoor air quality* because indoor air quality is currently being addressed by another PIER research program.

and energy market and end-use trends. Supplementing the general drivers and trends discussed earlier, this section describes the drivers and trends most relevant to outdoor air quality, devoting special attention to the generation, transmission, distribution, and use of electricity.

2.4.1 Regulatory Framework

To achieve or maintain ambient air quality standards, California has an air regulatory infrastructure that consists of local, State, and federal agencies. Programs are designed to issue permits to new pollution sources while making progress toward—or maintaining compliance with—State and federal air quality standards. As a result of these requirements, major stationary emission sources in California, such as electric power plants, are subject to a complex array of siting, permitting, emissions control, and emissions monitoring requirements. Likewise, non-major sources may also be subject to the complexities of the air quality requirements. These requirements are based on the federal Clean Air Act (CAA) and California Clean Air Act (CCAA), and on regulations specified by the State air districts. The most important of these regulations include those for new source review (NSR), best available control technology (BACT), lowest achievable emission rate (LAER), maximum achievable control technology (MACT), new source performance standards (NSPS), and best available retrofit control technology (BARCT). In addition to BACT, many large pollution sources may be subject to emission offsets, and therefore, need to obtain emission reduction credits to ensure a net decrease in emissions into the air basin.

2.4.1.1. Federal Legislation

U.S. Environmental Protection Agency

The EPA establishes national ambient air quality standards, and the states have to establish the emissions targets needed to achieve and maintain compliance with these standards. When states fail to establish adequate standards, EPA promulgates emission targets through federal implementation plans.

Federal Clean Air Act

Passed in 1963 and amended in 1970, 1990, and 1997, the federal Clean Air Act (CAA) forms the basis for the majority of air quality measures in the United States. Individual states are given the task of implementing many of the requirements set forth in the Act.

New Source Review

New Source Review (NSR) is a permit program that is operated on both the federal and State levels. The federal program draws guidance from the federal CAA, and the California program follows the requirements of the CCAA. Prior to the 1990 Clean Air Act Amendments, the vast majority of permitting was done by State and local agencies. Title V of the 1990 Clean Air Act Amendments created a federal permit program that can be administered by State and local programs. These programs issue permits for new stationary sources of emissions, so that emissions will not exceed the national ambient

air quality standards (NAAQS) set for the six criteria pollutants.[10] Under NSR permits, all major new and modified stationary sources must use Best Available Control Technology (BACT) to control emissions. BACT is defined as "…an emissions limitation (including a visible emissions standard) based on the maximum degree of reduction for each pollutant subject to regulation under the Clean Air Act which would be emitted from any proposed major stationary source or major modification which the Administrator (EPA), on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable…." (40 CFR 52.21(b)).[11]

In contrast to BACT (which applies to criteria pollutants), maximum achievable control technology (MACT) is a federal emissions limitation oriented towards hazardous air pollutants and is based on the best demonstrated control technology or practice used on a comparable source that emits at least one of the 188 federal hazardous air pollutants (HAPs) named in section 112 (b) of the federal Clean Air Act. Under California law, these pollutants are known as toxic air contaminants. The EPA is attempting to undertake a combustion-coordinated rulemaking on HAPs that would apply to stationary sources (e.g., boilers and turbines). Currently, for natural-gas-burning power plants, MACT is required when the plant emits more than 10 tons per year (tpy) of toxic air contaminants. Emission factors reported recently by the EPA seem to indicate that conventional power plants using gas turbines can emit more than 10 tpy of toxic air contaminants (mainly acetaldehyde, formaldehyde, and acrolein). It is unclear at this time how power plants in California will be affected by MACT, but it is important to note that two energy-related projects are in the top 10 facilities for on- and off-site releases of toxics in California (EPA 2000e).[12]

New Source Performance Standards and Best Available Retrofit Control Technology

New source performance standards (NSPS) are uniform emission standards that are established by EPA and applied nationally. They limit the amount of pollution that can be emitted from new sources or established sources undergoing modifications.

The best available retrofit control technology (BARCT) designation applies only to existing sources, and sets air emissions limits based on the maximum reduction achievable. The limit is established after examining environmental, economic, energy, and other impacts. BARCT varies from district to district, depending on its air quality designation, sources of pollutants, and contribution to the problem. If one air quality

---

[10] Criteria pollutants are sulfur dioxide (SO_2), particulate matter less than or equal to 10 microns (PM_{10}), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3), and lead (Pb).

[11] The State BACT is often equivalent to the federal Lowest Achievable Emission Rate (LAER). The federal BACT is not a major issue in California, because it only applies to areas in compliance with national ambient air quality standards. Also, an area may be in attainment for one pollutant and in nonattainment for another one. In this case, the federal BACT requirement only applies to the pollutants and its precursors for which the area is already in attainment.

[12] The two facilities are a power generating facility and a cogeneration plant in a chemical plant that produces soda ash; the emissions associated with the cogeneration plant are likely coming from the chemical plant.

management district adopts a BARCT requirement, it does not mean that other districts will adopt the same requirement. Consequently, the affect of BARCT on existing power plants will be on a district-by-district basis.

Prevention of Significant Deterioration (PSD) Permits

The New Source Review permit program includes Prevention of Significant Deterioration (PSD) permits that apply to new sources in areas in compliance with the NAAQS. For example, a facility may need a PSD permit for carbon monoxide (CO) and New Source Review (noncompliance) permit for ozone precursors. In this case, the facility must install federal Lowest Achievable Emission Rate (LAER) requirements for NO_X and volatile organic compounds (ozone precursors) and federal BACT (which is less stringent than the State BACT) equipment to control CO. Federal PSD permits, whether issued by delegated air districts or the EPA, are subject to review by the EPA Environmental Appeals Board (EAB). Although the two appeals filed to date to the EAB have been denied, the Energy Commission expects more appeals to be filed with the EAB, particularly for power plants in locations where there is public opposition. The Energy Commission is consulting with EPA in an effort to reduce this source of delay by providing definite timelines or expedited review for some project categories.

Environmental Justice

Environmental justice can be perceived as a driver, environmental issue, and a research issue. It is clear that any analysis of the causes, impacts, and mitigation of air emissions must include an assessment of environmental justice. Environmental justice concerns are addressed in federal law and affect all agencies receiving federal funds, as a result of Title 6 of the Civil Rights Act. In addition, Executive Order 12898 ("Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations") directs federal agencies to address environmental justice issues.

Environmental justice is an important issue with regard to electricity generators, the development of transmission and distribution infrastructure, and emissions credit trading. Because emissions credits can be traded, and because it is difficult to monitor air quality near all major emissions sources, it is possible for pollution hot spots to be created within specific air basins. If a high concentration of cumulative emissions falls within a minority or low-income community, environmental justice concerns must be addressed.

2.4.1.2. State Legislation

California Air Resources Board

The California Air Resources Board (CARB) was established in 1967 to address healthy air quality, conduct research into the causes and solutions of air pollution, and explore solutions to mobile emissions in the State. CARB sets ambient air quality standards for the State and oversees implementation of 35 Air Pollution Control Districts that conduct air quality management over stationary sources. In addition, CARB addresses mobile source emissions and combines and submits all of the districts' air quality management

plans to EPA. CARB is developing a Strategic Research Plan in parallel with the PIEREA effort (CARB 2001).

California Clean Air Act

The California Clean Air Act (CCAA) was passed in 1988. It offers a comprehensive framework for air quality regulation by outlining the State's air quality goals, planning mechanisms, regulatory strategies, and standards of progress. It requires air districts to attain State ambient air quality standards by the earliest possible date. Standards and provisions of the CCAA do not always match those of the CAA. For example, ambient standards for both ozone and PM_{10} are more stringent in the CCAA.

New Source Review

In California, each of the 35 Air Pollution Control Districts manages its own NSR program, based on rules and regulations that comply with State and federal law and reflect the unique needs of that district. Each district issues a permit to construct—and after construction, a permit to operate—which should comply with the federal NSR requirements, including PSD requirements. In cases where the district does not have a permit to grant PSD permits, the applicant must obtain a PSD permit directly from EPA. In California, BACT is often the same as the federal LAER designation. For example, the Bay Area Air Quality Management District (BAAQMD) defines BACT to be the following for any source (except cargo carriers): (1) the most effective emission control device or technique which has been successfully utilized for the type of equipment comprising such a source; (2) the most stringent emission limitation achieved by an emission control device or technique for the type of equipment comprising such a source; (3) any emission control device or technique determined to be technologically feasible and cost-effective; or (4) the most effective emission control limitation for the type of equipment comprising such a source which the EPA states is contained in an approved implementation plan of any state (BAAQMD 1998). In contrast, the San Diego Air Pollution Control District considers cost-effectiveness (e.g., dollar per ton of pollutant reduced), rather than the most stringent level, as part of the BACT determination (personal communication from Shirley Rivera, Resource Catalysts, January 12, 2001).

Environmental Justice

Environmental justice is a very important issue in California. The Energy Commission addresses environmental justice matters through its power plant siting and repowering evaluations. The California Air Resources Board is addressing environmental justice issues through its Community Health Program. Senate Bill 115 (signed by the governor on October 6, 1999; 1999 Statutes, Chapter 690) established the Governor's Office of Planning and Research as the State coordinating agency for environmental justice. Senate Bill 89 (signed by the governor on January 18, 2001; 2001 Statutes, Chapter 2) requires CalEPA to convene a working group on environmental justice to develop and help implement State environmental justice strategies.

2.4.1.3. Local Legislation

Air Districts and Air Quality Management Plans

Air districts are responsible for achieving and maintaining compliance with ambient air quality standards required by the federal CAA and the CCAA. Every three years, State law requires California air districts to develop air quality management plans (AQMPs). Districts in nonattainment areas are required to prepare a plan outlining how they will achieve compliance, and districts in attainment are required to prepare a plan showing how they will maintain compliance. These AQMPs take into account the population and economic growth of the districts for which they are prepared.

CARB compiles, reviews, and submits these AQMPs to EPA in what is known as a State Implementation Plan (SIP). The Clean Air Act requires each state to submit a SIP, which describes in detail how the state as a whole intends to attain national ambient air quality standards by the dates prescribed by EPA.

AQMPs are designed differently, to reflect the local or regional nature of the air quality conditions. Local air pollutants include directly emitted criteria pollutants, such as carbon monoxide, nitrogen dioxide, sulfur dioxide, lead, hydrogen sulfide, and primary particulate matter. Regional air pollutants include tropospheric ozone (formed by the interactions between volatile organic compounds and nitrogen dioxide) and secondary PM (particulate matter formed as a result of chemical reactions between gases).

AQMPs designed for regional pollutants have not been as successful in achieving compliance with established ambient air quality standards, even though they have generally resulted in decreased levels of ambient pollutant concentrations in the most populated areas of the State. An incomplete scientific understanding of how regional air pollutants are formed, accumulated, and transported in the atmosphere, along with the difficulty of achieving needed reductions, has hindered the task of reducing regional pollutants. Both the South Coast Air Quality Management District (SCAQMD) and the San Joaquin Valley Unified Air Quality Management District have made progress on improved models that will help better this understanding; however, the situation is complicated by the extreme difficulty of accurately assessing natural and anthropogenic emissions from all sources.

Some air districts are required by CAA to submit Rate of Progress Plans (ROPs), which are, in general, embedded in the SIP. ROPs are designed primarily to reduce Reactive Organic Gas (ROG)[13] emissions at the rates mandated by the federal CAA.

Because of restructuring and the potential for the development of many new electric generation facilities, air districts are reevaluating the role of power plants in their air quality attainment strategies and AQMPs. In this context, developers and air districts are facing key decisions concerning: (1) the availability, acquisition, and resultant price

[13] Reactive organic gases are photochemically reactive gases that may contribute to smog formation. They are composed of non-methane hydrocarbons, and are sometimes referred to as non-methane organic gases, or NMOGs.

effects of emission offsets; (2) appropriate changes to existing rules; and (3) the selection of BACT for certain emissions. For example:

- The price and availability of offsets will continue to influence the locations of proposed power plants. In particular, offsets for PM_{10} are becoming more difficult to obtain. Where offsets are scarce, interpollutant trading and new emission reduction incentive mechanisms may be needed to maintain progress toward attainment of air quality standards, while providing the offsets needed to facilitate power plant development and other economic development projects.
- Districts are seeking to expand the universe of emission reduction credits (ERCs) through the introduction of intersector ERCs. These include ERCs from area sources (e.g., home furnaces and water heaters) and mobile sources. As a result of their efforts, agencies are considering new regulatory strategies to ensure that complex offset proposals—such as those including interbasin, interpollutant, and mobile offset options—will comply with public health-based air quality standards. However, districts are faced with opposition to the expansion of the ERC market. For example, there is an emerging local community preference that developers provide local offsets rather than reducing emissions on a regional basis, as is allowed by most air districts. And the transfer of credits between mobile sources and stationary sources has become a key environmental justice issue.

Some of the retrofit rules adopted in the recent AQMPs required power plants to reduce emissions by a factor of 10. It is unclear to what degree, if any, the AQMPs due in 2003 will mandate further emissions reductions.

AQMPs and Power Plant Siting

The Energy Commission is responsible for issuing permits to all thermal power plants in California with a capacity of 50 megawatts or more. During each application's review, the pertinent air management district prepares a Determination of Compliance, which assesses the project's ability to comply with local air quality rules and regulations. Energy Commission staff then prepares an analysis to determine the project's environmental impacts and requires mitigation measures, as needed. AQMPs are very important in the mitigation of impacts for regional pollutants (Franco 2000). Site-specific analyses can play a significant role in assessing the impact of air quality regulatory strategies in addressing regional air quality problems, and the AQMP can provide key information about a plant's potential impacts.

Environmental Justice

In addition to activities at the federal and State levels, there is interest in environmental justice at the local level. The South Coast Air Quality Management District established a 10-point Environmental Justice initiative in 1997, and later, an Environmental Justice Task Force. The Bay Area Air Quality Management District also has an Environmental Justice Working Group to help the district implement its Guiding Principles of Environmental Justice.

Implications

Federal, State, and local regulations and regulatory agencies are key driving forces affecting air quality issues related to the generation, transmission, distribution, and use of electricity. It is expected that new regulations will lead to new environmental issues that the State must be prepared to address, and that these regulations will affect the location of new power plants, the timing of the siting process, and the ability of existing power plants to continue operating.

2.4.2 Impacts, Trends, and Future Implications for Electricity

2.4.2.1. Decreasing Air Quality for Some Regions

Air quality in most air basins in California has been improving, despite continued growth of the State's population and economy. However, most Californians live in areas that continue to violate the State's one-hour ozone standard, and with the exception of four rural counties, the entire State is designated as being in nonattainment with the State particulate matter (PM_{10}) standard (CARB 1999). Implementing the new national $PM_{2.5}$ standard proposed by EPA may change designated areas. For example, areas currently meeting federal PM_{10} standards (e.g., the San Francisco Bay Area) may be designated nonattainment areas as a result of the tighter $PM_{2.5}$ standard (Franco 1996). Until recently, the top four metropolitan statistical areas in the nation with the worst air quality (i.e., not meeting federal ambient air quality standards) were all in California: Riverside / San Bernardino, Los Angeles / Long Beach, Bakersfield, and Fresno (Ventura was the sixth worst area) (EPA 2000f).[14] The air districts with the most severe air quality problems are not expected to attain ambient air quality standards until late in this decade. NO_X emissions remain a related, problematic issue; however, combinations of technological developments and policy action could bring about a dramatic, positive change.

NO_X

The main air pollutant emitted from gas-powered power plant stacks is oxides of nitrogen (NOx)[15]—a precursor for ozone and particulate matter—which is regulated under both State and federal ambient air quality standards. Although NO_X emissions have been reduced to the point that all areas in California are now in attainment of NO_2 ambient air quality standards, NO_X emissions are still of concern, because they are precursors for ozone and particulate matter. Ground-level ozone (the primary constituent of smog) is not emitted directly into the air, but is formed by the reaction of volatile organic compounds (VOCs) and NO_X in the presence of heat and sunlight. Ozone continues to be a pervasive pollution problem throughout many areas of California and the United States (see the *Tropospheric Ozone* subsection below).

---

[14] The Houston metropolitan area now has the worst ozone pollution in the nation (SCAQMD 2000).

[15] NOx is commonly used to describe NO and NO_2. Although the State is in attainment of the NO_2 federal standards, NO_2 is a criteria air pollutant and a precursor to ozone and PM, which have health, visibility, and property-damaging effects.

By far, the greatest source of NO_X in California is on- and off-road mobile sources (CARB 2000a). In fact, mobile sources contribute almost 80 percent of total NO_X emissions in California (CARB 2000a; CEC 1998a). On an annual statewide basis, the electricity generating sector contributes about 2.2 percent of the State's total NO_X emissions (CARB 2000a). Emissions comparisons at different regional and temporal aggregation levels clearly show that electricity generation is a significant contributor to NO_X emissions. On days when ambient air temperature is high, this contribution increases greatly as greater electricity demand requires increased generation, which subsequently produces more NO_X emissions from the generation sector.

NO_X emissions from the generating sector are expected to decrease in the future, as emission control retrofit rules are implemented for existing power plants and more efficient new or repowered facilities displace and replace the old ones**.** At the same time, NO_X emissions from all sources (including on-road vehicles) are also expected to decrease significantly, as existing and new rules enter into full effect. For example, BACT rules are becoming more stringent as new control technologies come into the marketplace. For NO_X control, process technologies such as the use of overfire air and technologies such as SCONOX™ and XONON™ are being considered as viable options to selective catalytic reduction. Unlike many previous NO_X-reduction options, these technologies do not require the use of ammonia, a hazardous material, which can contribute to particulate air pollution. Moreover, it is claimed that SCONOX also reduces CO and VOCs; may be used to achieve high reductions of NO_X emissions from gas turbines, internal combustion engines, and industrial boilers; and can reduce NO_X in some applications without water. The technology is certified by CARB.[16] Hence, SCONOX and XONON are promising technologies for NO_X control, especially to achieve NO_X emissions levels lower than BACT, and they may eventually push BACT levels lower.

Power plant plumes are highly buoyant, with relatively high NO_X concentrations (with respect to background levels), and they typically rise well above the height of their stacks. The effective plume height may reach 200 meters or more, depending on atmospheric conditions and stack height. This altitude facilitates the transport of pollutants over long distances and, in some cases, to regions that would not be expected to be affected from just examining conventional surface-level meteorological data. As a result, NO_X–rich plumes may reduce ambient ozone concentrations near the power plant, but may increase ozone concentrations far from the source by transport of NO_X and/or VOCs. The NO_X plume may also facilitate a more rapid production of nitric acid and, perhaps, a more efficient production of secondary particulate matter. Long-range transport of pollution is now a more pressing problem than before, and power plant emissions may play an important role in regional pollutant transport. In addition, mixing and transport of pollutants aloft may also be a very important source of

[16] Information on SCONOX can be found on Goal Line Environmental Technologies' Web Site. www.glet.com/pr_sconox1.htm. Information on XONOM can be found on the Catalytica Energy Systems Web Site: www.catalyticaenergy.com/home.html.

secondary PM formation during the wintertime, when California experiences its highest PM concentrations.

Particulate Matter

Particulate matter originates from a variety of sources, including diesel trucks, power plants, wood stoves, and industrial processes. The chemical and physical composition of these particles varies widely. Those particles that are less than or equal to 2.5 micrometers in diameter are known as fine particles (e.g., $PM_{2.5}$) and further subdivided as ultrafine if less than 0.1 micrometers in diameter; those between 2.5 and 10 micrometers are known as coarse particles.[17] Fine particles can be formed in the atmosphere from gases such as sulfur dioxide, nitrogen oxides, and volatile organic compounds. Ultrafine particles are commonly formed from high temperature combustion and subsequent condensation of non-volatile material (e.g., inorganic metallic species). Coarse particles are generally emitted from sources such as vehicles travelling on unpaved roads, materials handling, crushing and grinding operations, and windblown dust.

By far, the greatest sources of PM in California are road dust[18], windblown dust, construction and demolition, farming operations, residential fuel combustion, and waste burning and disposal (CARB 2000a). On an annual statewide basis, the electricity generating sector contributes about 0.25 percent of the State's total PM emissions and 0.37 percent of the State's total PM_{10} (CARB 2000a). Although power plants produce a relatively small fraction of the total PM inventory, natural-gas-fired turbines (the technology of choice for new generation) may preferentially produce ultra-fine particles.

Scientific studies have linked particulate matter, especially fine particles (alone or in combination with other air pollutants), with a series of significant health problems, including: premature death; respiratory-related hospital admission and emergency room visits; aggravated asthma; acute respiratory symptoms, including aggravated coughing and difficult or painful breathing; chronic bronchitis; decreased lung function that can be experienced as shortness of breath; and work and school absences (EPA 1997). In addition to the elderly, other at-risk groups include individuals with preexisting heart or lung disease, children, and asthmatics.

Particulate matter is a major cause of visibility impairment in many parts of the U.S. (e.g., some area visibility has been reduced by 70 percent). Fine particles can remain suspended in the air and travel long distances: for example, the visibility problem in the Rocky Mountain National Park is attributed partially to emissions from a power plant in Arizona that supplies power to the Los Angeles Department of Power (EPA 1997; personal communication from Chloe Weil, EPA, February 8, 2001). In addition, airborne particles can also cause soiling and damage to materials.

---

[17] There are inconsistencies in the use of the term "coarse." Some experts refer to particles greater than 10 micrometers as coarse particles.

[18] Recent studies indicate that the amount of PM_{10} from paved roads may be less than predicted in the CARB inventory (Venkatram and Fitz 1998).

After a steady decline over the past decade, PM_{10} emissions appear to be on the rise again in California, although it may be too early to confirm that trend (CARB 1999). CARB states that almost all Californians breathe air that violates the State PM_{10} standards at least part of the year (CARB 1999). PM emissions are an important concern for the Energy Commission and the California Air Resources Board.

In 1997, EPA issued new federal standards for ozone and $PM_{2.5}$. However, in May 1999, the U.S. Court of Appeals from the District of Columbia set aside these new standards. The court removed the revised federal standard for PM_{10}, delayed implementing EPA's eight-hour ozone standard, and requested further comments on the new $PM_{2.5}$ standard. In February 2001, the U.S. Supreme Court upheld EPA's authority to set clean air standards based on health considerations, without considering the costs of meeting those standards, and left both the ozone and fine particulate standards in place. However, the Court ruled that EPA must revise its implementation of the ozone standard. Although these decisions have not had an immediate effect on air quality planning in the State, future standards will affect the types of control measures needed to attain compliance. As noted above, implementing the new national $PM_{2.5}$ standard proposed by EPA may make the San Francisco Bay Area a nonattainment area.

Tropospheric Ozone

Tropospheric ozone (O_3) develops when ozone precursors, such as hydrocarbons and NO_X, react with sunlight as they are blown through the air by the wind. Short-term (1–3 hour) and prolonged (6–8 hour) exposures to ambient ozone have been linked to a number of health effects of concern (EPA 1998; EPA 1999). Repeated exposures to ozone can make people more susceptible to respiratory infection, result in lung inflammation, and aggravate preexisting respiratory diseases such as asthma. Other health effects attributed to ozone exposures include significant decreases in lung function and increased respiratory symptoms such as chest pain and cough. These effects generally occur while individuals are engaged in moderate or heavy exertion. Active children playing outdoors during the summer, when ozone levels are at their highest, are most at risk of experiencing such effects. Other at-risk groups include adults who are active outdoors and individuals with preexisting respiratory disease such as asthma and chronic obstructive lung disease.

Ozone also affects vegetation and ecosystems, leading to reductions in agricultural and commercial forest yields, reduced growth and survivability of tree seedlings, and increased plant susceptibility to disease, pests, and other environmental stresses (e.g., harsh weather) (EPA 1998; EPA 1999). In long-lived species, these effects may become evident only after several years or decades, thus having the potential for long-term effects on forest ecosystems. Ground-level ozone damage to the foliage of trees and other plants can also decrease the aesthetic value of ornamental species, as well as the natural beauty of national parks and recreation areas.

Electric power plants contribute about 33 percent of the total NO_X emissions in the United States, and emit less than 1 percent of VOCs (Carlin ND). As mentioned earlier, the electricity generating sector in California contributes about 2.2 percent of the State's total NO_X emissions.

In California, statewide ozone levels have dropped dramatically in the past two decades (CARB 1999). Between 1980 and 1997, EPA's National Ambient Air Quality Standards' maximum peak 1-hour indicator dropped 49 percent at the same time that the State's population grew by 39 percent and the number of vehicle miles traveled rose by 78 percent (CARB 1999). Because most ozone is attributable to motor vehicles, this drop can be credited to stringent vehicle emissions controls.

During hot days, which are also usually associated with high ozone levels, power plant emissions increase above their annual average emissions. For this reason, during ozone violation days, the contribution of power plants to total NO_X emissions may be considerably higher than the average percentage. In addition, some power plants are concentrated in certain counties producing a substantial portion of the total NO_X emissions in these counties (Table 1). And as noted in the PM section, power plumes, with their relatively high NO_X concentrations, seem to produce more particulate nitrates, especially in the wintertime, when the highest PM concentrations are measured in most air basins in California.

Table 1. California Counties with the Highest NO_X Emissions from Electric Utilities and Cogeneration Facilities

County	NO_X Emissions (tons per day)
Los Angeles	13.92
Contra Costa	13.44
Kern	12.72
San Bernardino	5.58
Monterey	4.54
San Diego	3.79
San Francisco	3.76
Santa Clara	2.36

Source: California Air Resources Board (2000a)

Carbon Monoxide

Carbon monoxide (CO) is produced by incomplete combustion of hydrocarbon fuels and interferes with blood's ability to absorb oxygen. From 1980 to 1997, the maximum peak 8-hour indicator declined 26 percent (CARB 1999). Statewide CO emissions have also dropped, again thanks to the State's vehicle emissions controls. Only the South Coast Air Basin portion of Los Angeles County and Calexico (in Imperial County) violated the State and federal CO standards.

CO levels from stationary and area-wide sources are anticipated to increase slightly as the State's population grows; however, motor vehicles are by far the greatest contributor to atmospheric CO. Electric utilities produce less than 1 percent of the CO emissions in the United States, and 0.34 percent of the CO emissions in California (CARB 2000a). Permits for new power plants in California allow maximum CO concentrations of about

6 ppm in the stack. Although cleaner-burning gasoline helps reduce CO emissions, increasing motor vehicle use means that more strategies will be needed to control CO emissions. These strategies include the use of low-emission vehicles and measures to promote less polluting transportation alternatives.

Implications

In general, California has made great progress in reducing air emissions. Despite this success, State and federal regulatory agencies continue to target several critical pollutants (e.g., ozone, NO_X, and particulates). And air emissions in general will need to be tracked in order to assess their impact on the ecosystem (e.g., soil, vegetation, and surface water).

2.4.3 New Technologies and Energy Efficiency

As noted in the beginning of the section on general drivers and trends, renewable energy technologies, distributed energy resources (DER), and energy efficiency technologies and services are significant drivers that may have substantial impacts on California's air quality. Promoting and operating DER in California presents many challenges, but it also offers an opportunity to diversify the State's energy base and add crucial security to both State and regional energy economies. Some DER could significantly improve air quality through the promotion of clean power generation.

Support may build for DER as an answer to emergency situations where electrical generating capacity falls significantly short of demand, as is currently taking place in California. What remains in question is the degree to which a power emergency, while genuine in terms of generating shortfall, is the result of unexpected growth in demand, under-investment in new capacity, or poor operational decisions (e.g., reserving credits, upgrading emission controls, and maintenance). DER resources could be promoted to meet this shortfall. Developers may also invest in DER as part of the restructuring of the electricity industry in California, and rising electricity costs may encourage public and regulatory support for DER and drive private investment in DER facilities. In fact, the Energy Commission recently conducted a scoping study with EPRI to begin developing certification standards for DER, to help speed its introduction while ensuring environmental standards.

Because of the potential growth of DER as a generation and emissions source, there is a need to forecast emissions from the DER electricity-generating sector as input to AQMPs. However, this is a significant challenge because of modeling and analysis limitations. The pressure to develop DER in the State is likely to lead to increased demand for simpler, standardized air quality regulations for DER; however, care will have to be taken to ensure that these standardized regulations consider the range of emissions possible from DER. California SB 1298, enacted in 2000 (2000 Statutes, Chapter 741), addresses certification and uniform emission standards for DER by requiring that (1) the State board adopt "…a certification program and uniform emission standards for electrical generation technologies that are exempt from district permitting requirements by January 1, 2003," (2) emissions standards for DER "…be made equivalent to the level determined by the State board to be the best available control technology for permitted

central station power plants in California," and (3) "commencing on January 1, 2003, all electrical generation technologies shall be certified by the State board or permitted by a district prior to use of operation in the State." Although this certification will not be required until 2003, it demonstrates the State's intention to promote the use of clean DER.

Energy efficiency and load management technologies have been selectively promoted within California and in the nation at large. Well-managed efforts have demonstrated their ability to significantly reduce total demand, and to play a major role in regional power management. By the same token, energy efficiency and load management programs that are poorly managed or promoted can have negligible effect at substantial cost. As electricity demand around the State grows, active efforts to promote end-user efficiency and load management for both existing customers and those constructing new homes and apartments can be an important aspect of overall energy policy—and an important element of an air quality management strategy. For example, energy-efficiency and load management measures could be used partially as offsets or emission reduction control strategies in AQMPs—given the appropriate rule changes, the capability to quantify the impacts of the energy-efficiency and load management measures, and the ability to demonstrate that the emissions reductions are permanent and enforceable (as required by the Clean Air Act).

As noted previously, new technologies to control NO_X are being developed in the private sector. This has been spurred by regulatory requirements, the price for NO_X offsets, and RECLAIM trading credits in the Los Angeles area.[19] Two of the most promising technologies for NO_X control are SCONOX™ and XONOM™. SCONOX™ is a control technology that can control NO_X emissions to a 1 ppm level, while XONOM™ results in a lower combustion temperature, producing similar levels of NO_X emissions. Hence, regulatory driving forces are affecting private investment in the market of NO_X control techniques for large power plants and can, in principle and practice, be used for DER.

Implications

The promotion of new clean energy technologies (including energy efficiency) could play an important role in improving California's air quality. However, there are important questions that need to be resolved to ensure that these technologies are integrated in the State and federal regulatory framework. The introduction of new control technologies should make it easier for new power plants to be sited.

---

[19] The RECLAIM program was implemented in 1994 by the South Coast Air Quality Management District (SCAQMD). Facilities within the RECLAIM program have the option of complying with their allocation allowance by either installing control equipment or purchasing RECLAIM Trading Credits (RTCs) from other facilities. From the start of the program, the price of NOx RTCs remained relatively stable until the summer of 2000, at which time an increased demand for power generation resulted in the electric power industry purchasing a large quantity of RTCs. This action resulted in the depletion of available RTCs and caused the price of NOx RTCs for Compliance Year 2000 to increase from approximately $4,284 per ton traded in 1999 to approximately $39,000 per ton traded in the first 10 months of 2000 (SCAQMD 2001).

2.5 *Global Climate Change*

Increasingly, international and national attention is focusing on rising levels of greenhouse gases[20] (GHGs) in the Earth's atmosphere, partly as the result of human activities in producing and using fossil fuels. Addressing the potential ecosystem implications and resultant effects upon California's electric generation system raises at least two significant questions: to what extent is climate change likely to affect the way electricity is produced and used, and to what extent should California control the amount of greenhouse gases emitted from all sectors, including electricity generation?

Greenhouse gases produced by human activity are implicated as the principal driver of global climate change. The extent to which these gases have contributed to the observed increase in surface temperature in the Earth's atmosphere is still debated; however, the fact that the Earth's atmosphere is warming is indisputable. Most scientists have concluded that there is a direct link between increased carbon dioxide concentrations and the warming that has occurred since the industrial revolution. In fact, the Intergovernmental Panel on Climate Change (IPCC) concluded in 1995 that there is already a discernable human influence on climate. Modeling conducted by the IPCC initially projected that the Earth's global mean surface temperature may rise an additional 1.0 to 3.5 °C (1.8 to 6.3 °F) between 1990 and 2100 (U.S. Department of Energy's Energy Information Administration [USDOE/EIA] 2000a and IPCC 1995). More recent IPCC modeling projects that the global mean surface temperature could increase by 1.5 to 6.0 °C (2.7 to 10.8 °F) (Nakicenovic and Swart 2000; IPCC 2001). Changes of this magnitude can have a profound effect on climate.

Recent evaluations of the increasing atmospheric concentration of GHGs tend to indicate that potential major ecosystem changes could occur that would substantially affect electricity generation throughout the Western states grid. Changing precipitation timing and levels, as well as the warmer temperature influence on the magnitude and the duration of the snowpack, could drastically alter the availability of electricity generated by existing hydroelectric facilities within the system. In addition, the changes in the timing and level of rainfall will affect the timing and level of runoff. Such circumstances could lead to the potential reconsideration of water policies and priorities for all users, including fisheries, which in turn could place limitations on hydroelectricity production.

Increasing temperatures from global climate change would create both short- and long-term effects. Increasing temperatures over multiple-day intervals could, in the short-term, create electricity supply shortages in some portions of the system. In the long-term, increasing temperatures would, during summer months, create a growing demand for electricity, which if generated by fossil-fueled facilities, would create additional greenhouse gas emissions.

---

[20] Naturally occurring greenhouse gases include carbon dioxide (CO_2), methane (CH_4), nitrous oxides (N_2O), water vapor, and ozone (O_3) precursors. Human activities also produce those gases, in addition to synthetic greenhouse gases such as fluorocarbons (HFCs, PFCs, CFCs) and sulfur hexafluorides (SF_6).

2.5.1 The Regulatory Framework

2.5.1.1. International and Federal Legislation

Significant international efforts have addressed the climate change issue, which is critical given the global nature of the problem. At the United Nations Framework Convention on Climate Change (UNFCCC) held in May 1992, more than 100 industrialized nations signed an agreement to:

> ". . . achieve . . . stabilization of the greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." (UNEP/WMO 1992).

The FCCC was entered into force on March 21, 1994, and the Parties to the UNFCCC adopted the Kyoto Protocol for continuing the implementation of the UNFCCC in December 1997 (UNFCCC 1997). The Protocol requires developed countries to reduce their aggregate emissions by at least 5.2 percent below 1990 levels by the 2008–2012 time period. Although many countries are starting to address global climate change, this report only addresses the U.S. response.

The Kyoto Protocol requires the United States to reduce emissions by 7 percent below 1990 levels, to be achieved over the period from 2008 to 2012. President Clinton signed the Kyoto treaty on November 12, 1998. However, the treaty must be ratified by the U.S. Senate to be put into effect for the United States, and there has been little support for ratification of the Kyoto Protocol in the U.S. Congress without "meaningful participation" from the developing world. In July 1997, the U.S. Senate passed a 95–0 resolution directing the president not to sign any treaty that legally binds the U.S. to reduce emissions without commitment from the developing countries. The directive also specifies that no treaty that could harm the U.S. economy should be signed. President George Bush recently stated that he would not support the Kyoto Protocol as it was presently designed and that he would not regulate sources of CO_2 emissions in the United States. To date, little action has been taken at the national level to reduce carbon emissions. In 1998, CO_2 emissions were up 10.6 percent from 1990 levels (USDOE/EIA 1999).

The Energy Policy Act of 1992 (Section 1605) established a national inventory and voluntary reporting of greenhouse gases. The national inventory is updated annually and is based on data that are voluntarily reported to the U.S. Department of Energy's Energy Information Administration. The reports include GHG emissions, annual reductions of GHG emissions and carbon fixation by any means, and an aggregate calculation of GHG emissions by each reporting entity. The majority of reporters thus far have been electric utilities (USDOE/EIA 2000b).

The Clinton Administration developed initiatives to address global warming. For fiscal year 2001, President Clinton's budget included more than $4.1 billion for R&D of clean energy sources and technologies, energy efficiency, and other measures to reduce greenhouse emissions. In addition, President Clinton signed Executive Orders focusing on federal transportation fleets, development of bio-based products, and strengthening energy efficiency management in government—all at least partially dedicated to the

reduction of greenhouse gases. For fiscal year 2002, President Bush's budget for R&D provides less funding on this topic than that previously allocated.

In 1990, the Global Change Research Act (PL 101-606) established the U.S. Global Change Research Program (USGCRP) to coordinate federal research on this topic. The USGCRP recently completed a National Assessment of Potential Consequences of Climate Variability and Change (National Assessment Synthesis Team 2000). The work was managed by the National Assessment Synthesis Team—a group of experts from governments, universities, industry, and non-governmental organizations. The assessment not only focused on impacts to the United States as a whole, but also examined potential impacts to various regions of the country (see Section 2.5.2.1).

2.5.1.2. State Legislation

Presently, despite uncertainties associated with the precise timing, location, and extent of global climate change impacts, there is a trend among some State and local government agencies to consider early actions to reduce greenhouse gases. In California, about 12 cities, including Los Angeles and San Francisco, have developed, or are developing, climate change action plans to reduce greenhouse gas emissions (International Council for Local Environmental Initiatives [ICLEI] 2000).

In 1988, the California Legislature enacted AB 4420, which directed the Energy Commission to begin a study of the potential impacts of global climate change on California and to develop policies for reducing these impacts. The Energy Commission adopted its final report and submitted it to the governor and legislature in November 1991 (CEC 1991). Based on this body of work, California has adopted a no regrets approach since the early 1990s. A no regrets approach means that measures to reduce GHG emissions can also be adopted when they are justified based on considerations other than global climate change. For example, if certain energy-efficiency measures can be justified based on their own economic performance, they should be adopted under a no regrets framework.

In 1997, under a grant from EPA, the Energy Commission performed a preliminary analysis of options that the State should consider if a goal to reduce GHG emissions is adopted as a State policy. The report also included an inventory of GHG emissions for California using standard methodologies adopted by the IPCC (CEC 1998b).

In 2000, Governor Gray Davis signed SB 1771 (2000 Statutes, Chapter 1018), which creates a nonprofit corporation known as the California Climate Action Registry to record and register voluntary GHG emission reductions made by California entities. The bill also requires the Energy Commission to acquire and develop data and information on global climate change and provide State, regional, and local agencies, utilities, business, industry, and other energy and economic sectors with information on the costs, technical feasibility, and demonstrated effectiveness of methods for reducing or mitigating the production of GHGs from in-State sources.

Furthermore, SB 1771 requires:

- A State agency task force to be convened to ensure policy coordination on global climate change activities;
- A Climate Change Advisory Committee (representing business, major industrial and energy sectors, utilities, forestry, agriculture, local government, and environmental groups) to be established to hold public meetings and make recommendations to the Energy Commission on implementing international and national climate change requirements; and
- An inventory of statewide GHGs to be updated regularly, along with a public workshop on the inventory, and a posting of the report on the Internet.

It is anticipated that the research conducted under PIEREA will help address some of the issues being addressed in response to SB 1771, and vice versa.

For reducing CO_2 emissions from electricity generation, the Energy Commission is focusing on three strategies (CEC 1998a):

- Accounting for environmental externalities and incorporating their values in resource planning and procurement,
- Promoting high-efficiency gas generation, and
- Promoting the development and integration of renewable generation technologies into the electricity system.

2.5.1.3. Local Legislation

Local communities and governments have enacted energy-efficiency legislation in California over the last 30 years. Recently, local governments have been engaged in advancing the local implementation of the UNFCCC. More than 385 municipalities from 43 countries have joined the Cities for Climate Protection (CCP) Campaign sponsored by ICLEI (ICLEI 2000). The CCP Campaign goal is to reduce GHG emissions resulting from the burning of fossil fuels and other human activities. Cities in California participating in the Campaign include Berkeley, Chula Vista, Fairfax, Los Angeles, Oakland, Sacramento, San Diego, San Francisco, San Jose, Santa Cruz, Santa Monica, and West Hollywood.

In 1993, the City of Portland became the first U.S. city to adopt a carbon dioxide reduction strategy: the city established a reduction target of 20 percent below 1990 emissions by 2010—which is far more aggressive than the 1997 Kyoto Protocol, which, although not yet ratified by the U.S. Senate, sets a national reduction goal of 7 percent below 1990 levels by 2008 to 2012 (Portland 2000). Other California cities may adopt goals and plans similar to those of Portland.

Implications

Organizations at the international, national, State, and local levels are taking significant action to address global climate change concerns. California should be ready to participate in national and international discussions on options to reduce GHG emissions to make sure that its interests are protected. The implementation of SB 1771

creates the need for accurate information on emissions at the State level and the development of new methods for the accurate estimation of emissions for the organizations that would participate in this voluntary program.

2.5.2 Impacts, Trends, and Future Implications for Electricity

2.5.2.1. Global Climate Change and California: A Historical Perspective and Potential Climatic Changes

Overall, rainfall has decreased and temperature has increased in California over the last 100 years, according to the National Center for Atmospheric Research (NCAR) (Karl et al. 1995). Every global circulation model predicts increases in temperature in the Western United States; however, there is no agreement on modeling results with respect to changes in precipitation. However, most of the outputs from General Circulation Models (GCMs) predict a significant increase in precipitation in California.

A recent report by the Union of Concerned Scientists and the Ecological Society of America summarizes the technical literature regarding potential changes in California climate (Field et. al. 1999). According to this report, "…annual mean warming in the western United States reaches about 4°F (2°C) by 2030–2050. This corresponds to a winter warming of about 5°F (3°C) and a summer warming of about 2°F (1°C)." The same report indicates that the changes in the regional average temperatures mask the profound changes in climate at the local level that may happen in the next 100 years. Existing global circulation models do not have the level of geographical resolution needed to estimate changes in local conditions. This report also indicates that the potential increase in winter precipitation may fall more as rain than snow. This scenario would result in less water stored in the snowpack and, therefore, less water available during the dry season. Wilby and Dettinger (1999), however, suggest that increased precipitation may also result in more stored snow in high elevations. All the studies seem to suggest that increases in winter precipitation may result in an increased risk of flooding.

Climate change will also affect soil moisture. The effect of warming on soil moisture is one of the most difficult effects to predict; however, this effect is very important for the State because it will determine the amount of water that will be needed for irrigation.

As noted previously, the USGCRP's National Climate Change Assessment examined scenarios that might arise from a business-as-usual path, assuming no major interventions to reduce GHG emissions (National Assessment Synthesis Team 2000). The assessment looked at potential consequences at the national and regional scales, and also addressed implications for society and the economy. A major theme in the report was that, on the whole, the direct economic impacts of climate change on the national will be modest, but that on the regional and local scale, the impacts could be extensive. The report described the vulnerability of ecosystems to climate change and the economic implications of the disappearance, transformation, or fragmentation of these ecosystems.

For the West, the report noted possible impacts on water resources[21], natural ecosystems, agriculture and ranching, and tourism and recreation. Among the impacts predicted for the West was a reduction in snow pack that would alter the timing and amount of water supplies. Such a result could significantly affect both the delivery and use of water and the use of hydro for power generation. The first assessment addressed water, agriculture, human health, forests, and coastal areas and marine resources. Future assessments will likely address energy, transportation, urban areas, and wildlife. Although potential impacts were identified, mitigation measures are being addressed by other bodies, such as the IPCC, which recently released a report on climate change and land use and forestry (Watson et al. 2000).

Finally, the relationship between the El Niño Southern Oscillation and global climate change is not clear. However, some studies such as Timmerman et al. (1999) suggest that El Niño events may become more frequent in a global climate change scenario. El Niño events are often associated with extreme precipitation levels in California (i.e., very dry or very wet years), so the trend may be toward greater variability in rainfall.

2.5.2.2. Global Climate Change: Potential Environmental Impacts

Both terrestrial and freshwater flora and fauna in California are likely to become stressed in some of their current locations. As microclimates become stressful to local species and exotic species move in to compete for resources, they may need to migrate northward to survive. Some studies suggest that these migrations will have to be an order of magnitude more rapid than the maximum natural rates of range shift observed since the end of the last glaciations (Davis 1989; Dyer 1995).

Agricultural ecosystems will also be affected by the stress of climate change. Farmers who depend on trees and slow-growing vines may have difficulty maintaining yields and are likely to have difficulty finding suitable unused land. If they attempt to relocate, they may be hindered if the rate of climatic change is steep or switches from one state to another unexpectedly.

Air quality problems (e.g., ozone formation) may increase as a result of global warming. Hot days are usually associated with high ozone levels. For example, during hot days, power plant emissions increase above their annual average emissions in order to meet increased air-conditioning loads. Global climate change will have many other effects on California's environment and economy. California's wetlands, already diminished and stressed, may experience flooding as sea levels rise, and ocean waters may also begin to infringe on human habitation and infrastructure. Although the current rates of sea level rise (a few millimeters per year at most, primarily from the thermal expansion of warmer seawater) pose few immediate threats, some scenarios foresee rapid melting of the Greenland and/or Antarctica icecaps, which could lead to sea level rises of several meters or more over a century or two. Human developments such as roads, bridges, and

[21]A report on the potential impacts of climate change on the supply and demand for water and the resulting economic and ecological implications presents similar findings (Frederick and Gleick 1999).

coastal parks will need reinforcement as the ocean level increases. Other natural phenomena, such as wildfires, El Niño events, drought and floods, will have a greater impact on California if their frequency and intensity increase with climate change.

2.5.2.3. California Electricity System's Contributions to Climate Change

California's weather and unique resource mix results in GHG emissions that are different than those of many other states. For example, as shown in Figure 4, electricity generation in the California produced about 14 percent of all carbon-related emissions in the State in 1994, while the national average was 39 percent. However, when electricity generated outside of but delivered to California is included, electricity generation contributed 28 percent of all carbon-related emissions.

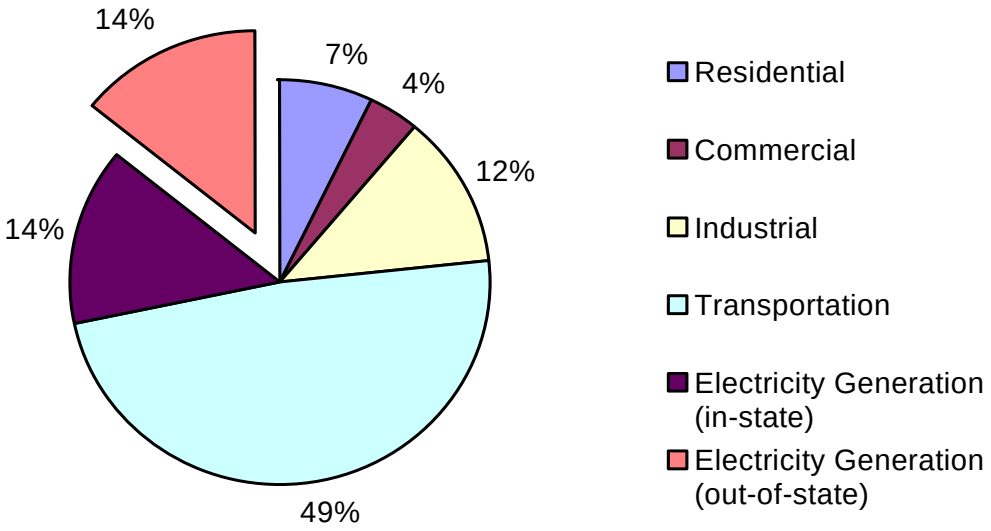


Figure 4. California CO_2 Emissions by Sector, 1994 [Source: CEC 1998c and 1998d]

Transportation contributes the greatest amount of human-produced carbon dioxide (CO_2) emissions in California—approximately 50 percent. This compares to the national average for the transportation sector of about 32 percent (CEC 1998c). As a result, the potential solutions to reducing GHG emissions and potential environmental impacts from GHG reduction scenarios in California will be different than the rest of the United States, and will need to be studied accordingly.

The per-capita emissions in California are about 40 percent lower than the per-capita emission of the United States as a whole (Franco and Loyer 1997). The comparatively lower carbon-related emissions from electricity generation are the result of a milder climate, the presence of less energy-intensive industries, and the lack of many coal-fired power plants in the State. In addition, some portion of lower CO_2 emissions can be

attributed to the State's no regrets energy policies that promote energy efficiency and renewable energy resources for electricity. At the same time, about 20 percent of California's power comes from out-of-state coal-fired facilities. Greenhouse gas emissions from these out-of-state facilities, however, are considered components of the emissions inventory in the states in which the facilities are located, and are not reflected in the above statistics.

As might be expected from the increasing overall efficiency of California's electric generation system, carbon emissions per GWh are expected to decrease somewhat over the next decade. However, despite this efficiency increase, overall carbon emissions from the electricity sector are expected to increase rather than decrease, because of growing electricity demand and the greater use of in-state, fossil-fueled generation.[22]

Methane and nitrous oxide contribute approximately 12 percent of in-state GHG emissions. This is a significant contribution, and their control may be, in some cases, much less expensive than CO_2 emission reductions from the electricity-generating sector. In fact, some recent studies indicate that including options to reduce non-CO_2 GHG emissions to comply with the Kyoto Protocol would reduce the costs of compliance by about 60 percent (Reilly et al. 1999). However, the methods used to estimate non-CO_2 GHG emissions are very uncertain, and additional work is needed to better estimate the emission levels from these gases.

2.5.2.4. Current Developments and Changes in the Electric Power Industry

Potential Impacts of Climate Change on Electricity Supply and Demand

Although the future impacts of climate change on California are uncertain, these changes—and the responses to them—can affect California's electricity system in three major ways: (1) changing the availability of electricity supplies, (2) altering the demand for electricity, and (3) changing the cost of electricity.

For example, in terms of electricity supplies, warmer winters would reduce the snowpack level and produce an earlier runoff, shifting hydroelectricity availability from spring and summer to winter and spring, when there is less demand for power. A preliminary estimate by the California Department of Water Resources of the impact of a 5.4°F (3.0°C) warming at Oroville Dam indicated that peak electricity production would decline by about 3–7 percent (CEC 1989).

Energy demands would also be altered, given warmer temperatures. In particular, air conditioning loads would likely increase, and water-pumping loads would likely rise. Depending upon supply and demand circumstances, these demands, as they increase peak loads, would also result in increasing the cost of electricity to consumers. Should federal carbon tax programs be developed or carbon emissions mitigation be required

[22] As part of restructuring, California power plants do not have any restrictions on the sale of power outside of California. Consequently, there may be greater use of in-state, fossil-fueled generation for selling energy out of state, leading to increased CO_2 emissions.

for generation facility licensing (as is presently the case in Oregon), costs of electricity to consumers would also rise (State of Oregon 2000).

Potential Impacts of Efforts to Improve Air Quality Conditions in California

Carbon dioxide emissions from the combustion of fossil fuels have decreased in California since the 1970s (CEC 1998c)—in part, because the State's power plants stopped burning residual and distillate fuel oils and switched to natural gas, which releases much less carbon to the atmosphere, per unit of energy released during combustion. The switch was implemented in part to reduce air pollutant emissions, allowing the different air basins in California to improve air quality conditions.

Vast regions in California are out of compliance with existing national ambient air quality standards. Districts out of compliance are developing air quality management plans (AQMPs) to bring the State in compliance with these national standards. In addition, the State has adopted more stringent ambient air quality standards that will require emission reductions beyond those needed to comply with the national standards. The AQMPs could help lower GHG emissions or at least reduce the rate of GHG emissions increases, depending on the control strategies in the AQMPs. There is a potential synergistic value in developing integrated plans to address both air quality and global climate change concerns, but such an effort is not currently required by the State government. A warmer climate may also hinder the State efforts to achieve compliance with ozone ambient air quality standards because higher temperatures are more conducive to ozone production.

Implications

Efforts to reduce GHG emissions would likely affect the California energy resource mix. In addition, global climate change itself will affect electricity generation and demand levels in 20 or more years, but there is a significant gap in our understanding as to how these impacts may unfold and how the energy system should evolve to be able to adapt to a changing climate.

2.5.3 New Technologies and Energy Efficiency

Analyses by several key climate and energy modelers indicate that significant research and development on GHG-friendly technologies is essential to achieving meaningful emission-reduction targets at affordable costs. Analysis of past energy-efficiency measures has shown significant savings. For example, five energy-efficient technologies have resulted in annual emissions reductions of 16 million metric tons of carbon (MtC) equivalent (Interlaboratory Working Group [IWG] 1997). A study conducted by five U.S. Department of Energy (DOE) national laboratories quantified the potential for energy-efficient and low-carbon technologies to reduce carbon emissions in the United States (IWG 1997). The study concluded the following: (1) a vigorous national commitment to develop and deploy energy-efficient and low-carbon technologies has the potential to restrain the growth in U.S. energy consumption and carbon emissions such that levels in 2010 are close to those in 1997 (for energy) and 1990 (for carbon); (2) all the scenarios (with reductions varying between 120 and 390 MtC / year by 2010) can produce energy savings that are roughly equal or exceed costs; and (3) the next generation of energy-

efficient and low-carbon technologies promises to enable the continuation of an aggressive pace of carbon reductions over the next 25 years.

California has traditionally adopted more stringent energy-efficiency measures than the rest of the nation. However, it has been difficult to ascertain the full impact of these measures on total energy consumption in the State because of the lack of detailed energy consumption data (Schipper and McMahon 1995). It seems that energy-efficiency measures have contributed substantially to the much lower energy per-capita consumption in California than the United States as a whole. Of the 30 percent lower consumption per-capita in California, it seems that 10 percent is attributable to energy efficiency; the rest is attributable to differences such as a milder climate and a less energy-intensive industry (Schipper and McMahon 1995). A recent study estimates substantial reduction in air pollutant emissions to the State from the implementation of energy-efficiency measures (Bernstein et al. 2000).

As discussed earlier, the electricity-generating sector contributes approximately 16 percent to the total carbon dioxide emissions from in-state sources. However, out-of-state power plants serving California generate more carbon dioxide than in-state power plants. With the current demand for power in California, it is possible that the contribution of the power-generating sector to in-state and out-of-state emissions would grow in the future. Hence, energy-efficiency technologies and programs in California will reduce carbon dioxide emissions in both California and neighboring states.

In California, investor-owned utility companies have been spending more than $200 million a year to commercialize energy-efficiency technologies. The Energy Commission has been spending more than $62 million a year on public interest energy research and development (including the development of new and emerging technologies) and more than $109 million a year on the development of renewable energy technologies. Publicly owned utilities in California are also required to spend equivalent amounts relative to their revenue requirements on Public Good Programs (i.e., societal improvement programs related to energy that have traditionally been conducted by utilities, but that are not adequately available in a competitive environment). In addition, local government, private industry, nonprofit agencies, and residential households are investing in energy-efficiency and renewable energy technologies.

Implications

The promotion of new clean energy technologies (including energy efficiency) could play an important role in lessening California's contribution to global climate change. These clean energy technologies could also provide increased clean generation, should existing generation technologies (e.g., hydroelectric) be adversely affected by the impacts of global warming. However, important questions still need to be resolved to ensure that these technologies are integrated in the State and federal regulatory framework.

3.0 Environmental Issues

3.1 *Issue Selection*

One of the most important tasks of this project was to select a group of environmental issues that would be the focus for research funding for the next few years. The selection of these high-priority environmental issues was based on an evaluation process that systematically examined a proposed list of 30 environmental issues. The proposed list is based upon an analysis of drivers and trends described in the previous section. These trends and drivers are based upon review of the literature and interviews with key stakeholders. A set of 23 criteria was used to evaluate the proposed list of environmental issues (Appendix C). These criteria included the following: perceived urgency; statewide significance; degree the issue is being addressed by others; probability for developing innovative solutions; and the potential for cost sharing. The evaluation criteria and measurement scale were used to help the reviewer better understand the issue and ultimately determine if it warranted first-year funding, a scoping study (smaller-scale investigative study of the issue), or consideration at a later date. For the measurement scale, higher numbers did not necessarily represent greater importance or value and were not counted as such; however, they helped the reviewer to understand the scope and the relative urgency of the issue. The evaluation process resulted in the selection of the following 11 environmental issues:

3.1.1 Environmental Issues

Aquatic Resources

- Electric power plants that use water for power production or cooling alter or eliminate natural ecological and hydrological functions in aquatic systems. These facilities affect riverine, estuarine, and marine systems, and they have contributed significantly to aquatic species decline. Adverse impacts include fatality from impingement (i.e., trapping aquatic organisms against intake screens) and entrainment (i.e., passing aquatic organisms through cooling systems and pumping intake valves and turbines); blockage of fish movement and migration; fragmentation of ecosystems; and alterations in normal stream flows and temperatures. Hydroelectric power plants that use water for energy production can impact aquatic resources through alteration of upstream and downstream habitat as well as by entrainment and impingement. Thermal power plants that use water for cooling can impact aquatic resources not only by impingement and entrainment at intake structures, but also may alter temperature and water quality around discharge structures.
- The cumulative impacts of multiple hydroelectric facilities on aquatic resources and terrestrial habitats in a watershed are difficult to evaluate, because of a lack of site-specific information and appropriate methodologies.
- Both electric power industry restructuring and the relicensing of hydropower projects are expected to affect the environmental management and stewardship of land and water resources by owners—including the potential for changes in peak power production and a shift in resource priorities. Although divestiture of

investor owned utility hydropower systems has been delayed by legislation, there is a need to better identify and understand these impacts.

Land Use and Habitat

- Wildlife and avian interactions with utility structures can result in electrocutions on poles used for distribution lines and collisions with transmission line conductors or wind turbines and supporting guy wires. Such interactions can result in negative impacts to birds, costly power outages, and violations of State and federal laws. Transmission line systems can cumulatively contribute to habitat loss and degradation, the primary factors leading to species endangerment and decreased biodiversity.

Outdoor Air Quality

- There is a need for improved methods, tools, and data to estimate impacts of emerging energy technologies (e.g., distributed energy) and fuels on air quality.
- There is a need for improved methods, tools, and data to quantify the air quality impacts of energy-efficiency and load management measures for preparing air quality management plan baselines and as offsets or emission reduction credits.
- Electricity generators and the development of transmission and distribution infrastructure can increase local air emission impacts and place a disproportional burden of those impacts on local minority and low-income communities.

Global Climate Change

- There is a need for improved methods and tools to translate global circulation modeling results to California regional climate, so that researchers can analyze the impacts of global climate change in California and an evolving electricity system in particular.
- There is a need for improved methods, tools, and data to: (1) develop simple and accurate guidelines to estimate the GHG emissions reductions in power plants that are attributable to the implementation of electricity conservation efforts; (2) prepare comprehensive inventories of GHG emissions (e.g., CO_2 emissions and their sources, methane emissions from the operation of hydropower facilities and other sources, N_2O emissions and their sources, and other GHG emissions and their sources); and (3) develop supply curves of GHG emissions reduction options.

Crosscutting

- When addressing the environmental impacts related to the generation, transmission, distribution, and use of electricity, concerns about aquatic resources, land use and habitat, air quality, and global climate change are intimately related. A whole systems approach is needed for understanding the interaction of all parts of the system, including growth, economic development, and new technologies; the influence of regulatory requirements; and how the impacts, benefits, and tradeoffs of different scenarios affect energy development and impact the environment. For example, it is not clear how future air quality management plans will contribute to efforts to reduce pollutants or if an

integrated approach would reduce the total cost to the State economy. Therefore, there is a need to coordinate and integrate programs and regulations that address aquatic resources, land use and habitat, air quality, and global climate change to avoid future penalties to the State economy from costly, uncoordinated efforts. [23]*

- There is a need for improved methods, tools, and data to estimate the benefits and impacts of emerging technologies (e.g. renewable energy) on air quality.*

The above 11 issues are proposed for funding in the coming fiscal year and described in Section 3.2. Two of the above issues, indicated by an asterisk, will be subjects of scoping studies to determine current knowledge and need for future research. The remaining 19 environmental issues (Appendix B) will be reevaluated and possibly funded at a later date. The connections between the high-priority environmental issues and the 19 environmental issues are graphically shown in Figures 6-9.

[23]Nine environmental issues are areas targeted for funding full-scale research projects. The two environmental issues denoted with an asterisk (*) require preliminary scoping studies to determine whether full-scale research projects should be initiated.

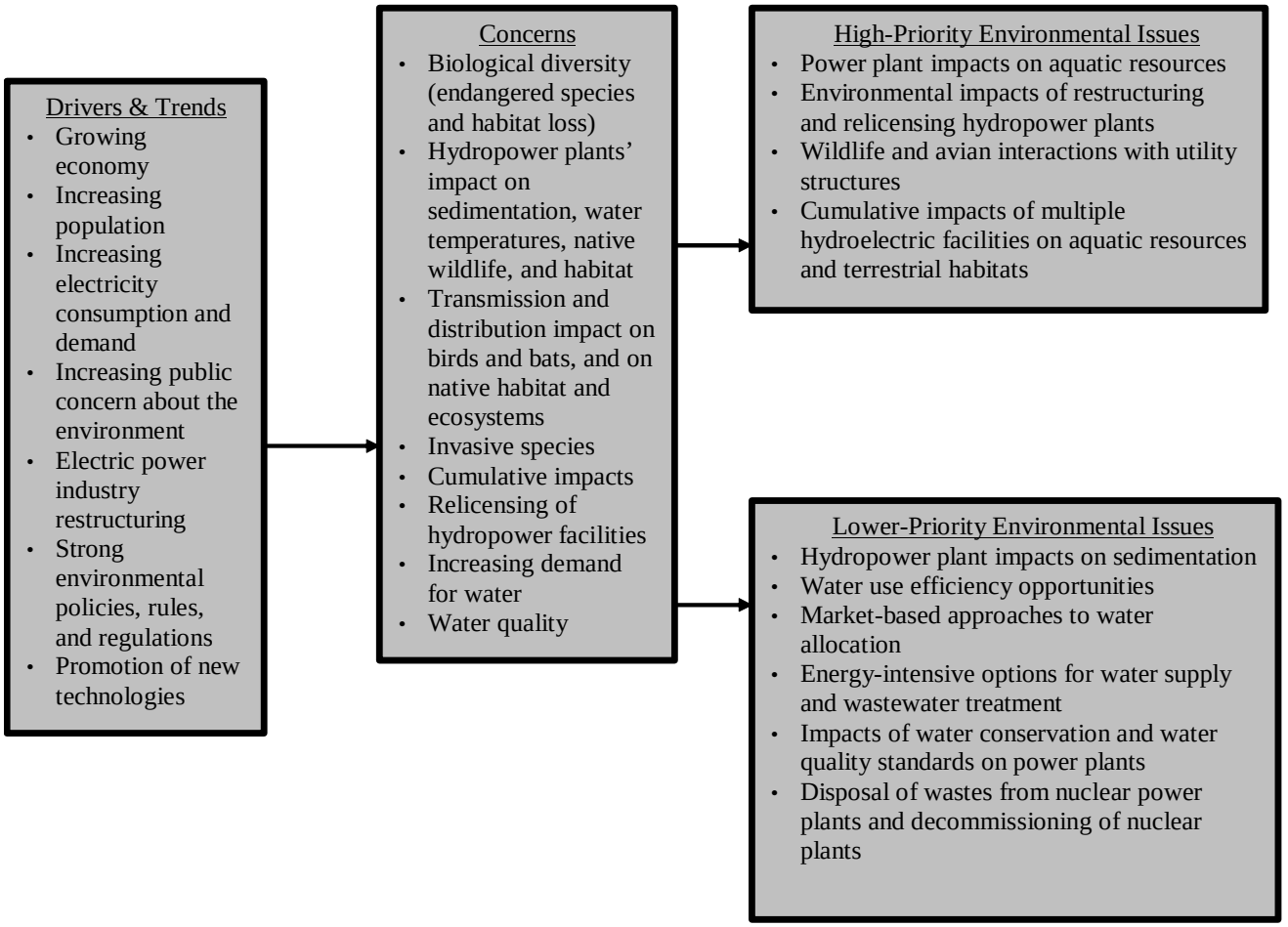


Figure 5: Aquatic Resources and Land Use and Habitat

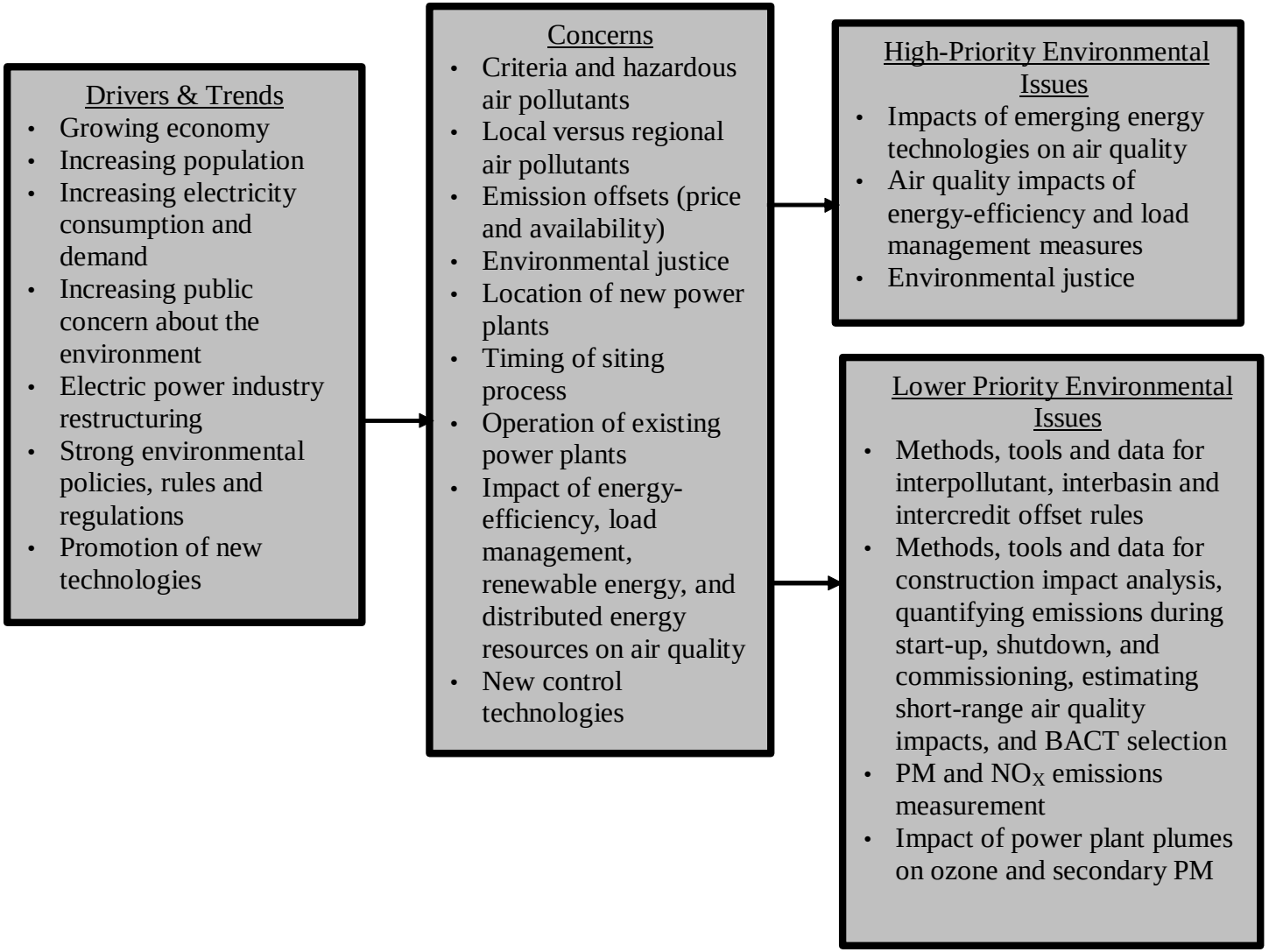


Figure 6: Outdoor Air Quality

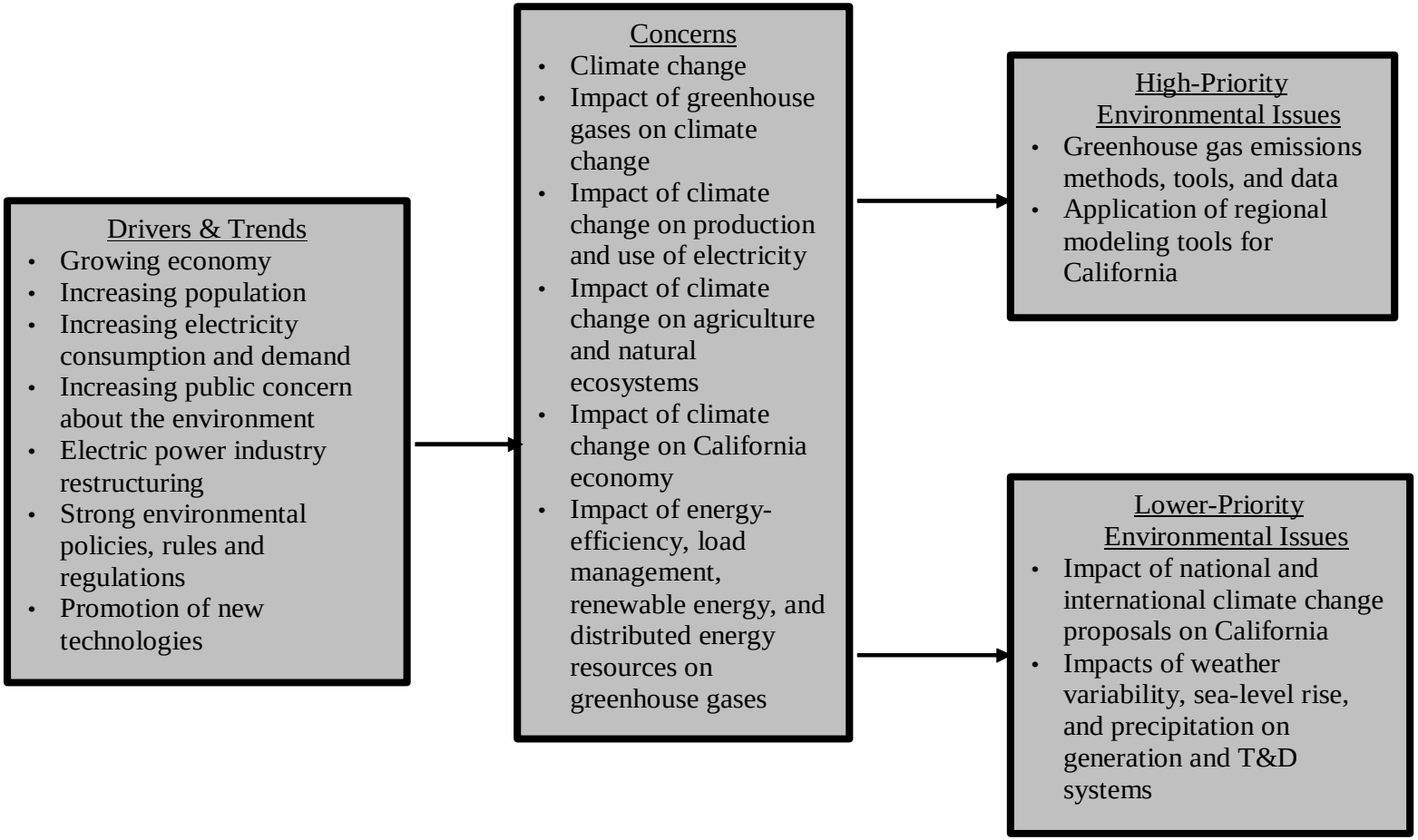


Figure 7: Global Climate Change

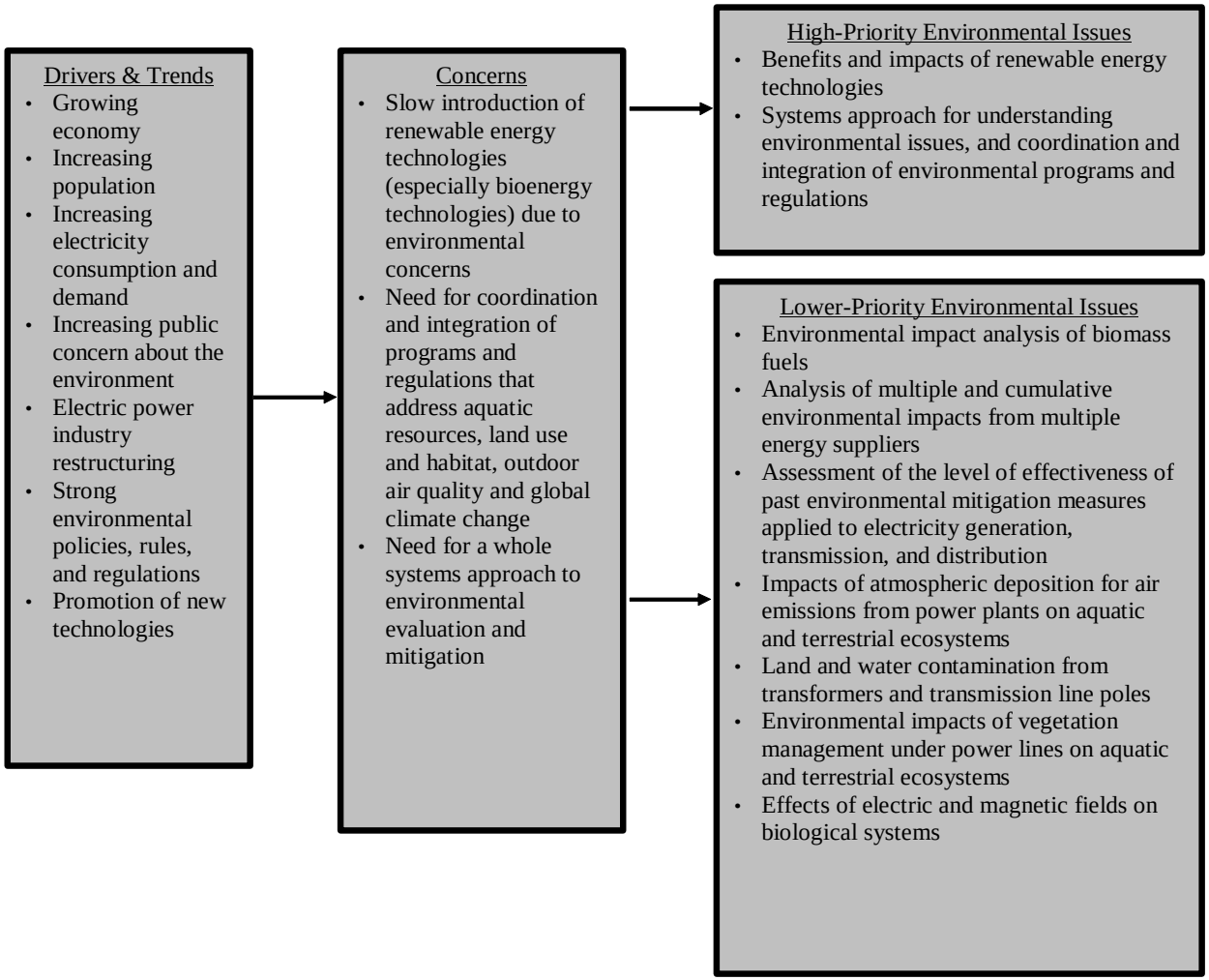


Figure 8: Crosscutting Issues

3.2 *High-Priority Environmental Issues*

This section discusses each of the environmental issues that were chosen as high priorities through the planning process described in Section 1.2.

3.2.1 Aquatic Resources

3.2.1.1. Power Plant Impacts on Aquatic Resources

Issue Statement

Electric power plants that use water for power production or cooling alter or eliminate natural ecological and hydrological functions in aquatic systems. These facilities affect riverine, estuarine, and marine systems, and they have contributed significantly to aquatic species decline. Adverse impacts include fatality from impingement (i.e., trapping aquatic organisms in intake screens) and entrainment (i.e., passing aquatic organisms through cooling systems and pumping intake valves and turbines); blockage of fish movement and migration; fragmentation of ecosystems; and alterations in normal stream flows and temperatures. Hydroelectric power plants that use water for energy production can impact aquatic resources through alteration of upstream and downstream habitat as well as by entrainment and impingement. Thermal power plants that use water for cooling not only impact aquatic resources by impingement and entrainment at intake structures but also may alter temperature and water quality around discharge structures.

Discussion

The impact of California's electric power plants on the State's aquatic resourcesis a significant concern. Impingement and entrainment associated with power plants are a locally significant cause of fish mortality. Hydroelectric dams are largely impenetrable barriers for fish passage upstream to spawning grounds and downstream juvenile migration. Changes in flows and temperatures affect productivity, migration, and habitat suitability, and can result in fish mortality from stranding, mortality to larval stages of amphibians, and the displacement of native biota by exotic species. Over two-thirds of the State's native fishes have either become extinct or have declined, largely as a result of cumulative impacts from hydro facilities and large dams, and attempts to mitigate adverse impacts of fossil power plants and hydropower facilities have met with limited success.[24] Impacts apply to a broad array of aquatic and semi-aquatic organisms such as amphibians, invertebrates, reptiles, mammals, and plants, but information available generally has been best for fisheries.

This issue is quite significant statewide, given that there are just under 1,400 jurisdictional dams in California and very few naturally flowing rivers or streams. Currently, 13 fish species are listed as endangered and threatened in the West, and many distinct groups are included within those species. Juvenile and adult salmonid species, predominant along the West Coast, have experienced dramatic declines as a result of both natural and human-induced factors in almost all river systems, with hydro or multi-function dams generally accepted as primary

[24] The populations of some fish species have increased (e.g., pikeminnow and other stillwater predators, and warm water fish that thrive in irrigation canals).

contributors. However, hydroelectric dams are not the only concern. Mortality from fossil fuel power plant water intakes is of concern in the Sacramento River Delta and marine estuaries.[25]

A better understanding of the affected environment, the interaction of generation facilities with the environment, and advances in analytical and mitigation measures will help improve policy- and decision-making. For example, no science-based thresholds for fish mortality or adverse effects on aquatic resources have become generally accepted, although standards are under development by recovery teams established under the Endangered Species Act (ESA) for various salmonid species and populations. In other regions of the country, regulators have determined that the values of affected fisheries exceed those of power generation, and have refused to relicense several dams. In addition, mitigation of impacts on listed fish and amphibians may also be required by USFWS or NMFS for salmonids, under the ESA, or by the State Water Resources Control Board (SWRCB) and/or EPA under the Clean Water Act, regardless of benefit-cost considerations.[26]

R&D institutions have partially addressed this issue. The Electric Power Research Institute (EPRI) has conducted several projects involving risk assessment, development of assessment models, development of fish protection systems, and ecosystem evaluation guidelines. Research has focused on the development of models that will determine the significance of impacts on a particular species population, as well as on technologies to reduce fish mortality and/or improve fish survival. Other research has focused on the correlation between operational practices (e.g., turbine efficiency) or use of devices (e.g., screens) and rate of survival. State and federal fisheries and water agencies (especially CDFG, USFWS, NMFS, Department of Water Resources (DWR), and some interagency programs, including CALFED and the Interagency Ecological Program) conduct or sponsor extensive fish population monitoring, and have researched screening technology for irrigation diversions. Oak Ridge National Laboratory (ORNL) is working on a series of case studies of the environmental benefits and costs of fish passage facilities.

Despite the above activities, much work remains to be done to address the environmental issues associated with power plant water use in California. Much of what has been learned is site specific. Major differences in project layout, species affected, flows diverted, and riverine systems require different design solutions. No single system or technology is biologically effective, operationally reliable, and economically feasible for all configurations. In addition, there is a need to collect more empirical data, because there is considerable variability in results between sites in prior studies. The fish protection issue is—and will continue to be—a prominent one in project licensing and toward long-term recovery efforts for each species.

---

[25] It is recognized that hydro operations provide multiple benefits, such as flood control, watershed management, water storage, and recreation. This Plan recommends further research in areas such as changes in operations, improved design and technology, and species behavior to better understand and address possible negative impacts of hydro facilities, so that the above benefits can be increased.

[26] In order to meet their responsibilities, State and federal resource agencies recognize that there is a need for ongoing monitoring of aquatic resources and water quality in riverine systems affected by hydroelectric production.

Other organizations are extremely likely to co-sponsor research for this issue, thus increasing the likelihood of developing innovative solutions. Agencies that have an institutional mission of fish preservation or restoration and are responsible for compliance with applicable regulations—such as USFWS, NMFS, CDFG, DWR, BLM, the U.S. Bureau of Reclamation (BOR), and the SWRCB—should benefit from projects addressing this issue. CALFED would likely be interested in collaborating on studies involving the Bay-Delta region. The University of California's Water Resources Center and the U.S. Geological Survey's National Research Program offer competitive grants programs that might offer funding to complement the PIEREA-funded projects.

The Energy Commission anticipates that the solutions developed to address this issue would very likely be implemented, provided that those solutions satisfy environmental concerns in a manner that did not impose overly burdensome costs on power plant operators.

3.2.1.2. Cumulative Impacts of Multiple Hydroelectric Facilities on Aquatic Resources and Land Use and Habitat

Issue Statement

The cumulative impacts of multiple hydroelectric facilities on aquatic resources and terrestrial habitats are difficult to evaluate, because of a lack of site-specific information and appropriate methodologies.

Discussion

It is widely known that hydroelectric facilities significantly affect aquatic and riparian ecosystems. The effects of dams on fisheries and other species have been studied, but the extent of the *cumulative* impacts of *multiple* dams in a watershed has yet to be coherently and comprehensively studied.

Estimating cumulative effects is of immediate regulatory importance. Such data are applicable to FERC relicensing requirements, ongoing reviews of most major rivers for Total Maximum Daily Load (TMDL) determinations, listing of increasing numbers of aquatic species (especially fish and amphibians) under State and federal Endangered Species Acts, and reviews of dams and watershed management policies under the Sierra Nevada Framework, the CALFED process, and other regional aquatic resource management processes. The California Environmental Quality Act also requires analyses of cumulative impacts, although this assessment is often lacking. However, litigation is increasingly forcing the assessment of cumulative impacts in environmental impact reports. With the increased listing of endangered species, heightened environmental awareness, and increased demand on water, the issue of cumulative impacts on aquatic resources and land use and habitat is particularly significant for California.

Most other institutions do not appear to be addressing the cumulative watershed impacts from hydropower generation. For example, EPRI's watershed and ecosystem projects assist its members with hydroelectric relicensing and pollution credit strategies, but the research does not focus on identifying and addressing the cumulative impacts of hydro operations. Watershed assessment methods are being developed in a large number of relatively uncoordinated efforts supported by CALFED, resource conservation districts, regional water quality control boards,

and a variety of watershed programs, but few of these involve controlled research studies on cumulative effects of hydro operations *per se*. Some fundamental research, much of it funded by EPA, is underway at the University of California campuses at Berkeley, Santa Barbara, and Davis (and probably at other universities) on the effects of varying flow regimes on watershed processes.

Several State and federal agencies and organizations should be very interested in co-sponsoring work to address this issue, as these agencies have expressed an intent to review hydroelectric project relicensing applications from a watershed perspective. Within the Sacramento Valley drainage area, such efforts are a high priority for CALFED. Any efforts to better understand cumulative impacts of multiple dams in watersheds would aid those efforts. The U.S. Environmental Protection Agency and the National Science Foundation (NSF) have active competitive grant programs in this area—under the Science To Achieve Results (STAR) program and others—and have annually funded several million dollars of academic research in California on watershed issues related to assessing and modeling cumulative impacts.[27] The University of California's Water Resources Center and the U.S. Geological Survey's National Research Program offer competitive grants programs that might offer funding to complement the PIEREA-funded projects.

Research on this issue is very likely to provide the methodologies and information that will enable researchers to evaluate cumulative impacts of hydro facilities on a watershed. Once these methodologies and data are developed, they will provide a sound scientific basis for hydro facility decision making and regulation.

3.2.1.3. Environmental Impacts of Restructuring and Relicensing Hydropower Plants

Issue Statement

Both electric power industry restructuring and the relicensing of hydropower projects are expected to affect the environmental management and stewardship of land and water resources by owners—including the potential for changes in peak power production and a shift in resource priorities. There is a need to better identify and understand these impacts.

Discussion

This issue is very urgent in California. Hydropower contributes almost 14,000 megawatts of electricity to the State. Electric power industry restructuring and the relicensing of hydropower projects could result in significant changes to this production. Potentially, new owners of hydro facilities (as a result of divestiture) have no mechanisms to pass stewardship costs onto ratepayers, whereas the regulated monopoly providers did. As a result, new owners will have incentives to divest non-income-producing assets, such as buffer zones above reservoirs, and to comply only minimally with costly environmental regulations. In addition, owners may operate the units more aggressively than they were operated in the regulated environment, which could lead to a greater impact on aquatic, as well as land, resources. Unless mechanisms are found to fund additional watershed and wildlife protection, the results could be substantial losses of

[27]The STAR program is the principal scientific extramural funding vehicle for EPA's various research authorities.

wildlife, fisheries, and open space. Development around now-protected water bodies could cause increased runoff, erosion, and contamination.

Changes in ownership and operations that impact watershed management could affect protection of watersheds, source water, and water supplies. Both rural and urban areas have a vested interest in seeing source water protected, and it is of particular importance for surface water sources such as lakes, rivers, and reservoirs above hydro plants that are used as a source for drinking water and could be affected by facility operations. Water agencies serving those areas, some of which are owners of facilities, have built understandings with the utilities over the years for hydro operations to meet watershed protection requirements and water supply needs. State and federal agencies, including the California Department of Heath Services and EPA, are conducting source water assessments that will make protection needs more clear.

This issue is significant statewide. Approximately 28 hydroelectric projects will be up for review in California in the next 10 years, and those applications will be subject to FERC's requirement to give equal consideration to both power and environmental impacts. Also, a review of PG&E's divestiture proposal is currently underway by the California Public Utilities Commission, and the State's other major utilities will continue their restructuring over the next three years. It is expected that with these restructuring plans will come new owners of facilities. At the same time, hydroelectric facility operators may be subject to increased requirements to address environmental impacts as part of FERC's relicensing process.

Although aquatic and land impacts attributable to the current relicensing and restructuring are not yet documented, these impacts are likely, and changes could have significant impacts on dam operations. The effects of restructuring and relicensing are interrelated though the outcomes of these actions can differ. Restructuring effects range from unknown to negative, while relicensing can result in environmental quality improvements. A clearer scientific understanding of the potential aquatic and land impacts from these activities will improve policy- and decision-making. Considering the urgent need for more electricity in the State, it is especially important to have data on these impacts now to inform the siting and licensing process, rather than have politically expedient decisions be made absent a sound scientific basis.

This issue has been partially addressed by other R&D institutions, but much research still needs to be conducted for California. EPRI is conducting research in this area; however, that research approaches the issue from the perspective of EPRI members, which are mainly utility companies. The U.S. Department of Energy has looked at restructuring generally, but not at this issue. The California Public Utilities Commission is looking at impacts of individual divestiture plans under CEQA, but not specifically for what restructuring could mean for environmental management in California. The U.S. Forest Service (USFS) has launched the National Hydropower Initiative to assess and coordinate the review of the many hydroelectric projects due for relicensing in the next decade, and the USFS's Pacific Southwest Region 5 is responding to electric power industry restructuring and relicensing by updating its regional hydropower strategy.

Several State and federal agencies have an interest in the changes that could occur as a result of restructuring and project relicensing, including USFS, USFWS, BOR, U.S. Bureau of Land Management (BLM), California Department of Fish and Game, and CALFED. Several of these agencies could potentially co-sponsor RD&D projects.

It is likely that research will identify and improve the understanding of environmental impacts from restructuring and project relicensing. Once data are developed, they can provide a scientific basis for both the CEQA review of restructuring proposals by the CPUC and the FERC process for relicense application review. Several federal agencies that have commenting authority in the FERC process could also benefit from these data. In addition to commenting authority, the U.S. Fish and Wildlife Service has mandatory prescription and recommendation authority under the Federal Power Act and Endangered Species Act. Improved data will also help regulatory agencies implement solutions that identify and address key environmental concerns associated with the restructuring and relicensing of hydropower projects, although any restructuring or shift of stewardship costs from private companies to taxpayers is sure to face political hurdles.

3.2.2 Land Use and Habitat

3.2.2.1. Wildlife and Avian Interactions with Utility Structures

Issue Statement

Wildlife and avian interactions with utility structures can result in electrocutions on poles used for distribution lines and collisions with transmission line conductors or wind turbines and supporting guy wires. Such interactions can result in negative impacts to birds, costly power outages, and violations of State and federal laws. Transmission line systems can cumulatively contribute to habitat loss and degradation, the primary factors leading to species endangerment and decreased biodiversity.

Discussion

Electricity is transmitted throughout the State via hundreds of thousands of miles of distribution (generally less than 60 kilovolts) and transmission lines. Wildlife and avian interactions with these lines can be beneficial (e.g., by providing nesting and perching and migration corridors), or detrimental (e.g., by causing collisions, electrocutions, and habitat fragmentation). Such interactions will increase with heightened demand for new lines from new generation systems and land developments. Wind developments are very land-intensive and are responsible for killing an estimated 750 raptors and unknown numbers of bats and migratory birds each year. Under the current demand for more energy production in the State, wind development is anticipated to increase.

Transmission lines cumulatively contribute to habitat loss and degradation when traversing through native habitats. The need to maintain low vegetation growth and maintenance roads along these lines generally promotes the invasion of exotic species to the detriment of native species. Although there is some thought that vegetated transmission corridors traversing disturbed habitats may facilitate wildlife migration corridors among otherwise fragmented habitats, little information is available in support of that concept. These rectangular patches of habitat have high perimeter-to-area ratios (edge effect), thereby increasing the influences of the adjacent, non-natural land uses and reducing the intrinsic value of the patch as a whole.

Collisions with, and electrocutions by, power lines can be biologically significant when they affect a population's ability to sustain or increase its numbers locally or throughout its range. Birds are electrocuted on the poles of distribution lines because designs place conductors and

groundwires close enough together that wings or other body parts can touch two hot spots simultaneously. Raptors are disproportionately vulnerable (at risk) because of their large size and attraction to power poles; poles provide perches for hunting, resting, feeding, and territorial defense. Electrocutions are documented throughout the State, and some single poles are responsible for thousands of deaths. Moreover, electrocuted raptors and other birds cause a significant number of power outages and grass fires annually. Collisions with power lines tend to occur most frequently with the uppermost ground wire and can result in high fatalities when lines span areas with high bird use. Little is known about the extent of this impact and, therefore, it's implications to avian populations. There are recent reports of significant localized mortality of large migratory water birds, including sandhill cranes and tundra swans, from collisions with power lines near wetlands. Some of the species involved are rare and local (cranes), and all have legal protection under wildlife laws and treaties.

Wind turbines and supporting guy wires can be responsible for large numbers of bird fatalities, especially to raptor species, but also to large flocks of migrating passerines. More recently, researchers are noting seasonal peaks in bat fatalities from wind farm developments, but bats have not been a specific focus of research conducted to date. In the Altamont Wind Resource Area, fatalities to golden eagles may be having a substantial affect on the local population. Additionally, large-scale wind developments are land intensive, requiring between 40–50 acres per megawatt.

Although research has been conducted to help document the problems, little is known about the statewide significance of these impacts, and solutions are still pending. Future research is needed to substantiate the theory of transmission line corridors enhancing migration, as well as the claims that these linear disturbances are significantly contributing to habitat degradation. Significant progress had been made in the last decade to understand causes of electrocution and collision risk; however, many solutions are still unproven or have proven ineffective. For example, collisions with conductors may be reduced by spacing or with marking devices designed to increase line visibility. However, intrinsic factors such as inclement weather, bird shape and behavior, and habitats affect the vulnerability to collisions. There are several designs for marking devices intended to increase line visibility. However, the efficacy of each design is not well known and needs further studies. Additionally, some devices work better for some species than others. Retrofitting, moving, or burying transmission lines to reduce collisions could be a significant economic challenge. Devices designed to insulate electrocution points on distribution lines have been developed. However, a recent study found that 37 percent of the devices installed were defective and ineffective, while 65 percent were installed improperly. Retrofitting lines to make them more bird-friendly is considered by utilities to be highly cost prohibitive. Wind energy research has been conducted on tower type, size, numbers, and placement, and some research has focused on avian vision and hearing. More studies and standardized methodologies and protocols are needed to develop nocturnal survey methods, evaluate the relative impacts of large versus small turbines, ascertain the efficacy of risk-reducing devices, and better understand the species-specific numbers of fatalities that constitute significance.

Avian mortality studies have been sponsored by various entities, including the Energy Commission, private sector firms (including wind energy companies), EPRI, DOE, the National Renewable Energy Laboratory (NREL), Raptor Research Foundation, the Energy Commission,

Edison International, and PG&E. The National Wind Coordinating Committee (NWCC) consists of a broad-based collaborative of stakeholders interested in addressing wind turbines and avian mortality. The Avian Powerline Interaction Committee (APLIC) consists mainly of utility interests and has been instrumental in providing workshops and publications that focus on electric systems tower designs to reduce collision and electrocution. Co-sponsorship opportunities with these organizations, as well as with USFWS and CDFG, are likely.

Historically, the pursuit of bird and bat mortality data at wind energy and transmission sites has been somewhat hindered by the reluctance of some power producers to share information regarding incidents of bird and bat electrocutions and collisions. Similarly power distributors are often reluctant to share information on bird electrocutions or collisions. However, the efficacy of mitigation measures is dependent on such data. USFWS has been increasingly applying pressure, through threats of shutdowns, permit violations, and steep fines, for utilities and wind developers to reduce impacts. Effective mitigation measures will enable the electricity system and wind turbine development to expand responsibly, and without violating the Migratory Bird Treaty Act, Bald Eagle Protection Act, and Endangered Species Act.

3.2.3 Air Quality

3.2.3.1. Impacts of Distributed Energy Technologies on Air Quality

Issue Statement

There is a need for improved methods, tools, and data to estimate impacts of emerging energy technologies (e.g., distributed energy) and fuels on air quality.

Discussion

Distributed energy technologies are electrical generation or storage systems located at or near load centers. Such systems are typically small (i.e., less than 50 MW) and modular. They may be located at a customer's premises on either the utility or customer side of the meter, or located at other points in the distribution system, such as a utility distribution substation. Distributed energy technologies include diesel engines, microturbines, small gas turbines, fuel cells, internal combustion engines, photovoltaics, solar dish Stirling engines, and wind, and may involve the use of combined heat and power. Configurations of distributed energy technologies include the installation of a single system or the aggregation of multiple units. Many combustion distributed energy technologies use natural gas; however, backup generators (which are not used as primary electricity generators) mostly use diesel fuel.

As electricity demand in California grows, distributed energy technologies are often being proposed as a solution, particularly to meet short-term peaking needs. Because these technologies can be put on-line in a short time at a low cost (relative to traditional generation units), the California energy market and regulators are likely to be confronted with many proposals for distributed energy technologies in the next few years. Fossil-fueled distributed generation will add emission streams near ground level and will therefore potentially have more local impacts. Some of these impacts may be avoidable if proper precautions are taken to reduce emissions from generators (e.g., in meeting certification standards), if they are to be operated more routinely.

As a result, the need for improved methods, tools, and data to estimate the air quality impacts of these technologies represents a pressing need throughout the State. Distributed energy technologies that generate less than 50 MW fall outside the Energy Commission's power plant siting jurisdiction, and the California Public Utilities Commission is not required to issue permits for these units unless an investor-owned utility owns the facility. Therefore, permitting and approval for most distributed energy technologies has fallen to the cities, counties, and air districts (jurisdictions having little experience with permitting the newer distributed energy technologies), or has been altogether missing.

Until recently, California had not developed uniform emission standards for the permitting of distributed energy technologies, but the expected growth of these units in the State has prompted legislation to create such standards. Senate Bill 1298 (signed by the governor on September 25, 2000; 2000 Statutes, Chapter 741) requires the California Air Resources Board (CARB) to establish uniform standards for distributed energy technologies that reflect the best performance achieved in practice by the distributed energy technologies that are exempt from district permitting. Those standards must then match the BACT levels for central station power plants at the earliest practicable date. CARB is also developing permitting and certification guidance for units that fall under their jurisdiction.

Energy planners and regulators need effective methods, tools, and data to evaluate the implications of new distributed technologies on emission levels within air districts and to assess the effect of differing strategies for meeting air quality plan attainment dates (e.g., including the extended operation of standby generators during energy shortages). Other environmental impacts, such as noise pollution and waste heat, should also be investigated. Regulators will also need to evaluate environmental impacts to author rules that protect public and environmental health, as well as to determine any economic benefits that power producers might receive, such as emissions offsets. Without adequate methods, tools, and data to address the environmental impacts of distributed energy technologies, California regulators will be unable to forge sound, science-based regulations that will ensure public and environmental health—and new environmentally preferred technologies may have greater difficulty in gaining competitive market entry.

Although several research organizations are investigating the development of these technologies and promoting their commercialization, only two studies have examined the air quality impacts associated with these technologies: one sponsored by the California Air Resources Board (Iannucci et al. 2000) and another sponsored by The Energy Foundation (Lents and Allison 2000). There is clearly a need for further investigation.

Because of the substantial interest in developing, promoting, and using these technologies, the Energy Commission expects that costs could be shared with CARB, DOE, EPA, EPRI, the Gas Technology Institute (GTI), and others. The Energy Commission anticipates that solutions will most likely use existing methods and tools or adapt them from existing emissions procedures and equipment, which is likely to help ensure the success of projects addressing this issue. Once developed, these solutions should be easily implemented.

The Energy Commission predicts that better methods, tools, and data will facilitate the successful widespread introduction of distributed energy technologies in California, while ensuring that these technologies contribute to better air quality in the State.

3.2.3.2. Air Quality Impacts of Energy-Efficiency and Load Management Measures

Issue Statement

There is a need for improved methods, tools, and data to quantify the air quality impacts of energy-efficiency and load management measures for preparing air quality management plan baselines and as offsets or emission reduction credits.[28]

Discussion

This is a very important issue in California, and is particularly applicable to rulemaking and the operation of energy-efficiency and load management programs. Quantifying the impacts of energy-efficiency and load management measures would contribute to a variety of benefits. It would enable regulators to judge how much importance to assign to energy efficiency and load management in determining offsets, better inform the public of the value of energy-efficiency and load management measures, and could assist in bringing more energy-efficient products to market. Improved energy efficiency often lowers total life-cycle costs for both producers and consumers, and therefore benefits the economy directly.

Recent legislation (Assembly Bill 970, signed by the governor on September 6, 2000; 2000 Statutes, Chapter 329) requires the Energy Commission to invest significantly in peak electricity demand reduction programs to help ensure that the State will meet its energy needs. As a result, many see the promotion of energy efficiency and load management as a prime alternative to building new electricity generation in the State. In fact, energy efficiency and load management has been a cornerstone of the State's energy policy for more than 20 years, and this strategy is generally considered to have helped reduce energy demand. However, there has been little effort to quantify those benefits, contributing to the skepticism about the impact of these measures on air quality. Quantifying the benefits of energy-efficiency and load management measures as part of the baseline of air quality management plans and as offsets or emission reduction units would be a significant milestone in both the energy and air quality sectors. Energy-efficiency offsets (regionally or at the air district level), or accounting for energy-efficiency and load management emission reductions in a plan's forecasted inventory, could provide more regulatory flexibility in air quality plans regionally or at the air district level, which would benefit the economy. Finally, a market for these measures would be created, producing multiple secondary public benefits that flow from increased energy efficiency.

Energy-efficiency and load management measures affect energy demand, and therefore, the quantity of electricity and air emissions generated. Improving methods, tools, and data to estimate the impact of energy efficiency and load management on the environment is a crucial step toward incorporating energy-efficiency contributions into regulations. Policy makers and decision makers will not use energy-efficiency and load management measures as offsets of emission reduction units until they are confident that these measures actually improve air quality and that the emissions reductions are permanent and enforceable (as required by the

[28]Energy efficiency measures (e.g., wall insulation, high-efficiency appliances, and compact fluorescent lighting) reduce load by decreasing electricity consumption. Load management (e.g., energy storage, time-of-use rates, and interruptible or curtailable service options) shift portions of demand from peak to off-peak periods or to create a more flexible load shape.

Clean Air Act). Therefore, quantifying the environmental (and particularly, air quality) impacts of energy efficiency and load management is essential to strategic planning and rulemaking.[29]

This issue has been partially addressed by other R&D institutions, although not to the extent envisioned in the issue statement. The California Institute for Energy Efficiency (CIEE) and LBNL have conducted investigations in this area; both organizations have examined the air quality implications of tree planting and whiter surfaces on roofs of buildings, but they have not examined the implications for offsets in particular regions in the State. The EPA is helping Northeast states redesign their air quality management plants to meet their NO_X commitments by accounting for energy-efficiency measures in their inventory. The RAND Corporation prepared a report for the Energy Commission on air quality impacts from energy-efficiency (Bernstein et al. 2000). The State of Texas has an effort under way to quantify the benefits of energy efficiency and renewable energy. The Western Interstate Energy Board (WIEB), an organization of 13 Western states and three Canadian provinces, is preparing a guidebook to explain the opportunities and procedures for incorporating energy efficiency and renewable energy measures under Section 309 of EPA's regional haze rule. The Western Regional Air Partnership (WRAP), a collaborative effort of tribal and state governments and federal agencies, will be modeling the impacts of energy efficiency and renewable energy measures on air emissions (and ultimately regional haze). And the Energy Commission has funded work on the role of energy efficiency in reducing ozone.

Several organizations would be interested in co-sponsoring this type of analysis: EPA, CARB, and possibly DOE, the South Coast Air Quality Management District (SCAQMD), WIEB, and WRAP.

Improved methods, tools, and models are likely to be developed to address this issue. Already, some models have been developed for the South Coast and Sacramento regions and additional models can be developed for other regions. The EPA analysis conducted in the Northeast and the WIEB and WRAP analyses could also be transferred to California. Once the models have been developed and refined, they could be used by key regulatory agencies at the local, regional, and State levels.

3.2.3.3. Environmental Justice

Issue Statement

Electricity generators and the development of transmission and distribution infrastructure can increase local air emission impacts and place a disproportional burden of those impacts on local minority and low-income communities.

Discussion

California law (Senate Bill 115, (signed by the governor on October 6, 1999; 1999 Statutes, Chapter 690) defines environmental justice as "… the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies." Because of an expanding

[29]The Independent System Operator does not consider the environmental impacts of available energy sources, other than NO_X, when dispatching power (CEC 2001a).

economy and population, California faces an increased demand for electricity. As a result, many new facilities will have to be built in the next few years, along with extensive energy-efficiency activities. In the context of California electricity generation, environmental justice most often becomes an issue when repowering existing facilities, or when siting new electricity generators or transmission and distribution infrastructure. The siting process addresses environmental justice issues by helping to ensure that plant siting will not disproportionately affect minority and low-income portions of the communities in which they are built.

Regulatory agencies involved in the siting process examine environmental justice issues as part of the proceedings. Thermal electricity generators with a rated capacity of 50 MW or larger are granted permits to build and operate by the California Energy Commission. Smaller-capacity generating equipment is either issued a permit by the local air district or requires no permit (depending on capacity size and projected hours of annual operation). CARB is developing a certification program and uniform emission standards for electrical generation technologies that are exempt from district permitting requirements. CARB helps to ensure that power plants are constructed in compliance with all applicable laws, ordinances, regulations, and standards.

Historically, environmental justice evaluations have addressed large central generating power plants, and have therefore been handled by the Energy Commission. However, the State is expected to experience an influx of distributed generation (DG) units (many of which have a capacity less than 50 MW) in the near term, which means that air districts may need to evaluate permits for an increased number and variety of generating units. In addition, combustion-based DG units could potentially exacerbate the problem of increased emissions. Some combustion-based DG generators are not as clean-running as modern central generating plants, partly because emission controls are currently either unavailable or not as effective as those of state-of–the-art central power plants. Moreover, most DG units do not use tall stacks to carry emissions from the area, which increases local exposure. CARB is currently working on regulations and guidance for the approval and use of DG in the State.

Generally, an evaluation of environmental justice issues must characterize air quality in existing minority and/or low-income areas, characterize the impacts of a new power generating facility, assess the health and welfare impacts on the local population that would arise from the installation and operation of that facility, and identify potential mitigation opportunities. Siting evaluations must use unbiased scientific methods consistently, and also apply a consistent set of criteria (that is impartial to race and economic factors) to all potential sites.

Two elements are key to deciding whether to site a generator in a particular location:

- The existing level of air toxics and criteria pollutants in the community being proposed for the site
- Sound data on potential local air toxics and criteria pollutants from a proposed generating unit

However, available data on existing concentrations of emissions (i.e., before the installation of the power facility) and techniques to predict ground-level concentrations of air emissions in the immediate vicinity of the proposed power facility are often inadequate. For example, air quality assessments should evaluate the potential site (which may not have monitoring equipment in place), rather than a nearby site where monitoring equipment might already be located.

The evaluation must also predict the emissions and dispersion pattern of the proposed generating unit at that site, which can be a complicated endeavor. CARB's Neighborhood Assessment Program Work Plan (CARB 2000b) states that "…evaluating environmental justice issues and identifying difference in impacts among communities will require determining cumulative exposures, which is a technically difficult task." It also says that "…no clear guidance exists as to how to assess air pollution impacts at the neighborhood scale."

Ideally, an environmental justice examination should review not only the level and distribution of *emissions*, but also examine the distribution of *impacts*, perform dynamic analyses that consider those factors on a neighborhood level over time, and identify potential mitigation options. At this time, the need for improved methods, tools, and data make such an examination difficult.

For power plant developers, the prospect of increased local emissions from new or repowered power plants can bring about public opposition, which can slow or stop the development of new facilities. Without accurate data that are mutually acceptable between both the community and developers, siting discussions can grind to a halt. Addressing environmental justice concerns from the outset of the review process will facilitate the approval of suitable sites and mitigation strategies. There may be some reasons why certain areas, such as decommissioned military bases or brownfields, are a good site for power plant and transmission development.

Sound data on potential local emissions from a proposed power plant is a key element in the decision of whether or not to site the plant in a particular location. It also provides all the stakeholders with a picture of the magnitude of the potential facility's impact on the community. Given the pressing need for additional electricity in the State, the time for licensing new power plants has been reduced. A rapid review process will require a streamlined method for judging the appropriateness of a site, in regards to environmental justice, and accurate data for evaluation by all stakeholders.

Environmental justice issues associated with electric power plants in California have not been addressed by other R&D institutions, although related activities in California have been undertaken. CalEPA has a Working Group on Environmental Justice that is developing an interagency environmental justice strategy. CARB is examining environmental justice issues, but primarily through in-house analysis. It has a Community Health Program that addresses community air quality issues through a Neighborhood Assessment Program, Community-Based Air Toxics Evaluations, a Children's Environmental Health program, and an Indoor and Personal Exposure program. The Community Health Program's primary focus is to develop assessment tools and explore long-term policy options for addressing environmental justice issues. The Governor's Office of Planning and Research has an environmental justice steering committee that works with other agencies to coordinate policy around environmental justice issues, including environmental justice training. The South Coast Air Quality Management District and the Bay Area Air Quality Management District examine environmental justice issues in their respective regions. The EPA has environmental justice projects across the United States: currently, the only one in California is at Barrio Logan, near San Diego.

Work addressing environmental justice issues would involve a number of technologies and benefit a wide variety of stakeholders, so it seems likely that costs could be shared among many technology developers, researchers, and governments. As power plants become more difficult to site, being able to conduct accurate site-specific analyses will become crucial, saving time and money for all of the stakeholders involved, and helping to ensure the public health.

3.2.4 Global Climate Change

3.2.4.1. Development and Application of Regional Modeling Tools for California

Issue Statement

There is a need for improved methods and tools to translate global circulation modeling results to California regional climate, so that researchers can analyze the impacts of global climate change in California and the electricity system in particular.

Discussion

The increased need for electricity in California is spurring development of new electricity generation facilities. Because this fleet of generating units will serve the State for 30 or more years, it is important now to predict the impacts of global climate change on the ability of these facilities to operate. Siting evaluations for those facilities should consider the long-term impacts that global climate change may have on those facilities and on energy demand.

Regional modeling covers the research that needs to be done to develop better methods to estimate climatic changes at the State level. It is widely accepted by the scientific community that global circulation models (GCMs) do not provide a good estimation of impacts at the regional level. Global circulation models use very coarse grid resolutions, which means that California is represented by just a few modeling points. The existing GCMs do not see the coastal ranges, and the Sierra Nevada may be represented as a minor increase in elevation. This is in sharp contrast with reality, which suggests the need to downscale the global circulation results to obtain better representations of climatic changes at the local level.

Regional climate change should be interpreted in its broadest sense. This means that this area of research does not exclusively rely on mesoscale numerical meteorological models used to downscale coupled global circulation models. Regional climate change also entails the analysis of the paleoclimatic and historical climatic and hydrological record (to uncover ongoing trends that may be due to global climate change), statistical downscaling, and hybrid approaches combining statistical and numerical methods.

The recently completed third assessment report of the Intergovernmental Panel on Climate Change (IPCC) identifies this area of research as one of the priority areas that should be addressed before the preparation of the next evaluation of the state-of-the-science on global climate change (IPCC 2001). Similarly, the recent enactment of SB 1771 raises the prominence of this issue in California and at the Energy Commission.

Most climate scientists rely on the few well-recognized (highly published) GCM research groups that have generated climate change projections for the IPCC and related peer-review activities. Both Lawrence Livermore National Laboratory (LLNL) and Lawrence Berkeley National Laboratory (LBNL) are receiving funding from DOE to work a high-performance version of the National Center for Atmospheric Research's (NCAR) GCM.

Regional Climate Model (RCM) activities associated with climate change are somewhat limited. LBNL has conducted some preliminary work on examining climate change impacts in California with a regional climate model. At least three University of California institutions (Scripps Institution of Oceanography, UC Los Angeles, and UC Santa Cruz) are working on

different aspects of regional modeling. There are also a number of organizations that are generating various impact assessments in California, but these are based on GCM projections (e.g., agro-economics, water demand, and stream flow response), rather than regional models.

Several national and international institutions are engaged in long-term research programs designed to improve our understanding of the climatic system on earth. They are also focusing on the development of better global circulation models that incorporate new scientific findings. PIER funds will not be used to enhance these efforts, but will coordinate work with ongoing global model research programs. Work on regional modeling may also be expensive and other institutions are partially addressing what is needed for California. For these reasons, PIER funds will be leveraged, to the maximum extent advisable, with other funding to perform this work (e.g., the National Science Foundation's Climate Simulation Laboratory, or the Central Research Institute of the Electric Power Industry of Japan).

3.2.4.2. Greenhouse Gas Emissions Methods, Tools, and Data

Issue Statement

There is a need for improved methods, tools, and data to: (1) develop simple and accurate guidelines to estimate the greenhouse gas (GHG) emissions reductions in power plants that are attributable to the implementation of electricity conservation efforts; (2) prepare comprehensive inventories of GHG emissions (e.g., CO_2 emissions and their sources, methane emissions from the operation of hydropower facilities and other sources, N_2O emissions and their sources, and other greenhouse gas emissions and their sources); and (3) develop supply curves of GHG emissions-reduction options.

Discussion

There is an urgent need for more electricity generating facilities and more electricity conservation efforts, so that the State will be able to the meet projected electricity needs of its growing economy and population, and reduce its demand when advisable from an economic/environmental perspective. At least a portion of those facilities will release greenhouse gases that could contribute to global climate change. Power plants licensed and built today without sufficient information about their potential to emit GHGs could significantly affect overall GHG emissions, future efforts to mitigate them, and the cost of generating electricity for years to come.

The planning, licensing, and siting processes for electricity generating facilities needs adequate methods, tools, and data to incorporate electricity conservation efforts, GHG inventories, and supply curves of GHG emission reduction options into decision making. The lack of this type of information and tools could delay the siting of new plants, slow improvements to existing power plants, and reduce the motivation for pursuing cleaner energy technologies.

New methods and tools are necessary so that California entities will be able to provide accurate data to the California Climate Action Registry, as required by SB 1771 (even though California's total emissions are a very small portion of the global total that affect California's climate). The Energy Commission will use that data (as well as data that it generates itself) to provide information on global climate change and to provide State, regional, and local agencies, utilities, business, industry, and other energy and economic sectors with information on the costs,

technical feasibility, and demonstrated effectiveness of methods for reducing or mitigating the production of GHGs from in-state sources.

The information provided by new methods, tools, and data will enable energy planners and regulators to incorporate GHG considerations into licensing, planning, and regulations. It will also contribute to better GHG inventories and help planners design effective State programs that address global climate change (e.g., a State Climate Plan or specific programs that help the State's electricity system adapt to or mitigate global climate change). Because these planning and regulatory decisions are being made now, and will continue for many years, it is important that this research be conducted as soon as possible.

Some R&D institutions have partially addressed this issue, but not as a California-specific issue. DOE has developed emission factors for certain types of power plants at the national level, and regional emission factors have been developed for certain regions (e.g., Northeast and Ohio Valley areas). Supply curves of GHG emission reductions have been created at the national and international levels. Some utilities are analyzing the cost-effectiveness of recycling sulfur hexafluorides (SF_6) from transformers. EPA is conducting analyses of N_2O emissions. However, the Energy Commission is not aware of similar California-specific activities.

California has a dated inventory of GHG emissions, and SB 1771 mandates that this inventory be updated on a regular basis. The existing inventory does not provide information on the net changes in carbon from forestry and land use changes, because of the need for improved state-level data. For this reason, PIER funds may be needed to address this knowledge gap and properly address this sector in the revised inventory.

New methods, tools, and data will provide information on the role of electricity conservation efforts in reducing GHG, improving GHG inventories, and developing quantitative supply curves of GHG emission-reduction options. Greenhouse gas projects might include evaluating CO_2 emissions and their sources, methane emissions from the operation of hydropower facilities and other sources, N_2O emissions and their sources, and other greenhouse gas emissions and their sources.

By enacting SB 1771, California demonstrated a commitment to the study of GHG and their effect on the environment. The law requires that a State agency ensure policy coordination on global climate change issues and that a Climate Change Advisory Committee, consisting of stakeholders, be established to explore the issue and make recommendations to the Energy Commission. As this coordination begins, opportunities for co-sponsorship of projects that could substantially leverage the PIER funds are likely to arise. For example, one potential partner would be the U.S. Global Change Research Program (USGCRP)—a multi-agency national research program that includes the Departments of Agriculture, Commerce, Defense, Energy, Health and Human Services, the Interior, and State; EPA; NASA; the National Science Foundation (NSF); and the Smithsonian Institution. For Fiscal Year 2000, the USGCRP budgeted $1.7 billion for global climate change research.

California has chosen to take a leadership role in the area of GHG emissions research; therefore, it is essential that accurate methods, tools, and data be developed so that regulators and generation planners can incorporate GHG considerations into the State‘s licensing, planning, and regulatory decisions.

3.2.5 Crosscutting

3.2.5.1. Coordination and Integration of Environmental Programs and Regulations

Issue Statement

When addressing the environmental impacts related to the generation, transmission, distribution, and use of electricity, concerns about aquatic resources, land use and habitat, air quality, and global climate change are intimately related. A *whole systems* approach is needed for understanding the interaction of all parts of the system, including growth, economic development, and new technologies; the influence of regulatory requirements; and how the impacts, benefits and tradeoffs of different scenarios affect energy development and impact the environment. For example, it is not clear how future air quality management plans will contribute to efforts to reduce pollutants or if an integrated approach would reduce the total cost to the State economy. Therefore, there is a need to coordinate and integrate programs and regulations that address aquatic resources, land use and habitat, air quality, and global climate change to avoid future penalties to the State economy from costly, uncoordinated efforts.

Discussion

Electricity industry restructuring is changing how California's electricity system affects the environment, and neither the effects of those changes nor the means of their mitigation are yet clear. As the structure of the State's new electricity system comes into focus, policymakers, decision makers, and regulators are making important determinations that will result in long-term effects on the environment. However, many of these decisions may suffer from a lack of coordination among all the stakeholders involved. Moreover, many of these decisions may be made without a recognition or comprehensive understanding of the linkages connecting air quality, aquatic resources, land use and habitat, and global climate change as they relate to the generation, transmission, distribution, and use of electricity.

The fate and transport of chemicals, for example, is complex and requires an interdisciplinary and integrated systems approach—as was demonstrated when California adopted MTBE as an gasoline oxygenate to improve air quality, only to discover its adverse effect on aquatic resources. Many laws have single-focused mandates, and it has been difficult for agencies to address multimedia effects. As a result, many State and federal regulations address environmental issues singly, rather than as a comprehensive whole (e.g., USDOE/EIA 2000c). This approach has led to end-of-pipe compliance, an increase in the time and expense involved in conducting research and drafting regulations, and a more difficult planning process for industrial companies. More effective and economical programs and regulations could be implemented by creating better linkages between agencies and by incorporating a whole ecosystem approach to environmental evaluation and mitigation (e.g., environmental life-cycle assessment provides a framework, approach, and methods for identifying and evaluating environmental burdens associated with the life cycles of materials and services from cradle to grave).

An integrated systems analysis of California's energy system is needed for examining how the different components of the energy system interact with each other and, ultimately, their impact on California's environment. The system components would include: generation, transmission and distribution, fuel supply and distribution, electrification, energy prices, distributed

generation, energy efficiency and load management, and the natural and human environment (e.g., air, land, water, recreation, aesthetics, and culture).

The Energy Commission is not aware of any single institution looking at these issues in a coordinated and integrated manner in California. CalEPA expressed an interest in this issue but does not appear to have any ongoing research projects to address it. Although other organizations might be interested in this activity, none have conducted this type of work. At the national level, there is increasing interest in addressing part of this problem. The State and Territorial Air Pollution Program Administrators (STAPPA) and the Association of Local Air Pollution Control Officials (ALAPCO) published a report that assesses strategies that simultaneously reduce conventional air pollution and GHG emission (otherwise known as harmonized strategies) (STAPPA and ALAPCO 1999). At the international level, the International Standards Organization (ISO) has developed a family of standards (ISO 14040) that describe the principles and framework for conducting environmental management life-cycle analysis.

It is immediately clear that integrated and coordinated policies could be developed in some areas (e.g., air quality and global climate change), and other opportunities to coordinate research and regulations should become apparent (e.g., the development of assessment models and indicators, environmental life-cycle assessment, integrated energy systems analysis, and a comprehensive environmental analysis of environmental justice). Once developed, key regulatory agencies could implement these solutions to reduce costs and streamline regulations.

3.2.5.2. Benefits and Impacts of Renewable Energy Technologies

Issue Statement

There is a need for improved methods, tools, and data to estimate the benefits and impacts of emerging technologies (e.g. renewable energy). Renewable energy technologies include: biomass/municipal solid waste, geothermal, hydroelectric, solar, and wind. These technologies can be distributed energy technologies, but may also represent larger-scale applications.

Discussion

Along with efforts in promoting energy efficiency and load management, California will add significant new electricity generation capacity in the near future to meet the burgeoning needs of a growing economy and population. State strategies to meet this demand will likely include an increased use of renewable energy technologies, particularly as some of these technologies are maturing and becoming more cost effective. California is rich with indigenous renewable energy resources, so various renewable technologies could be installed anywhere that is technically feasible. In recent years, California has significantly increased its financial support of renewable energy technologies through RD&D and the commercialization of these technologies. Four issues have surfaced as ones most important to the future development of renewable energy in California: affordability, reliability and dispatchability, power quality and safety, and environmental benefits (CEC 2001b).

The use of renewable energy technologies in California is expected to improve the environment (especially air quality) overall, but the specifics of each technology's contribution to that improvement is not clear. Just as important, the *adverse* consequences of renewable technologies

on different media (e.g., air, water, and land use) have not been clearly documented. In looking at potential negative impacts, the most important renewable technologies to examine are the various bio-energy technologies. The current utilization of biomass is low, but could become greater as bioenergy projects are used as an alternative to fossil-fuel-based generation. Until the environmental impacts of all renewable energy technologies are known, policy and planning decisions cannot be fully informed. For example, the renewable energy industry is interested in (1) developing methods, tools and data for better quantifying renewables' benefits; and (2) developing a system that would allow the sale of some renewables' air quality benefits as offsets regionally or at the air-district level, providing an additional incentive for the development of renewable energy technologies. Improved methods, tools, and data in this area are the key to quantifying these impacts in a way that would allow the implementation of such a policy.

Although some RD&D institutions have partially addressed this issue, that work has been far from comprehensive. The Energy Commission has looked at some of the air quality impacts associated with geothermal power. The National Renewable Energy Laboratory (NREL) has conducted many studies on renewable energy (including biomass: e.g., Morris 2000), but the Energy Commission is not aware of any California-specific studies that are using an integrated systems approach to evaluate the environmental benefits and impacts of renewable technologies.

The development of methods, tools, and data to estimate the benefits and impacts of renewable energy technologies is important worldwide. Governments, research entities, nongovernmental organizations, and renewable technology manufacturers would benefit from this work and should be interested in cost-sharing.

For renewable technologies that emit no air emissions, such as photovoltaics and wind turbines, evaluations could concentrate on avoided emissions from using these technologies and on impacts from their manufacture and installation (i.e., a life-cycle analysis that looks at the full fuel cycle benefits of renewable technologies). Studies of other technologies may require new methods or tools to measure such emissions, although examinations of biomass and landfill gas technologies could most likely use modified stack testing equipment and methods, in addition to the fuel cycle analysis. The cumulative, multimedia impacts (e.g., air, water, and land use) would also be addressed.

Once developed, the new methods, tools, and data would have widespread testing and decision-making applications among planners, developers, and regulators. In particular, regulators would use this information to either promote selected technologies or limit the introduction of those technologies that may impair air quality.

4.0 Next Steps

The 11 selected environmental issues discussed in this report will be the focus of funding awarded in the near-term by the Energy Commission. The selection of these issues is the first step in a process of defining goals, milestones, and strategies for RD&D in the topical areas of aquatic resources, land use and habitat, global climate change, and air quality. A major goal of this effort is to develop RD&D roadmaps designed to provide concrete public interest benefits to the electric ratepayers of California.

The process of defining these goals, milestones, and strategies will involve the creation of Planning Teams composed of individuals with specific expertise relative to the selected issues. These Teams include experts from academia, research institutions, and the regulatory community. At the draft stage of this planning effort, the Planning Teams will conduct a minimum of one workshop with the research community, regulators, and key stakeholders to discuss the key issues, future needs and implications, and specific RD&D projects to be developed. Using the issues as a basis and input from the workshops, these Planning Teams will prepare comprehensive research plans for consideration and possible adoption by the RD&D Committee of the Energy Commission.

The final step is implementation of the respective RD&D plans. An important element of implementation is the coordination of proposed RD&D with other possible co-sponsors. In addition, this step requires coordination with other regulatory agencies, formation of project steering committees, solicitation of proposals, executing contracts with researchers, and transferring research results to interested stakeholders.

Opportunities for funding will be noticed through the technical review group mail list and the Internet at www.energy.ca.gov.

5.0 Glossary

AQMD	Air Quality Management District
AQMP	Air Quality Management Plan
ARB	See CARB
BACT	Best Available Control Technology
BARCT	Best Available Retrofit Control Technology
BLM	Bureau of Land Management (U.S.)
BOR	Bureau of Reclamation (U.S.)
CAA	Clean Air Act
CADER	California Alliance for Distributed Energy Resources
CARB	California Air Resources Board
CCAA	California Clean Air Act
CDF	California Department of Forestry
CDFG	California Department of Fish and Game
CEQA	California Environmental Quality Act
CIEE	California Institute for Energy Efficiency
CPUC	California Public Utilities Commission
DER	Distributed Energy Resources
DOE	Department of Energy (U.S.)
DWR	Department of Water Resources (California)
EAB	Environmental Appeals Board
EPA	Environmental Protection Agency (U.S.)
EPRI	Electric Power Research Institute
ERC	Emission Reduction Credit
FERC	Federal Energy Regulatory Commission
GCM	Global Circulation Model

GHG	Greenhouse Gas
GRI	Gas Research Institute
GTI	Gas Technology Institute
IPCC	Intergovernmental Panel on Climate Change
LAER	Lowest Achievable Emission Rate
LBNL	Lawrence Berkeley National Laboratory
LLNL	Lawrence Livermore National Laboratory
MACT	Maximum Allowable Control Technology
N_2O	Nitrous Oxide
NCAR	National Center for Atmospheric Research
NMFS	National Marine Fisheries Service
NO	Nitric Oxide
NO_2	Nitrogen Dioxide
NO_X	Nitrogen Oxides
NREL	National Renewable Energy Laboratory
NSF	National Science Foundation
NSPS	New Source Performance Standards
NSR	New Source Review
ORNL	Oak Ridge National Laboratory
PG&E	Pacific Gas and Electric Company
PIER	Public Interest Energy Research
PIEREA	Public Interest Energy Research Environmental Area
PM	Particulate Matter
PSD	Prevention of Significant Deterioration
RCM	Regional Climate Model
RD&D	Research Development and Demonstration

RTC	RECLAIM Trading Credit
SCAQMD	South Coast Air Quality Management District
SIP	State Implementation Plan
SO_2	Sulfur Dioxide
SO_X	Sulfur Oxides
SWRCB	State Water Resources Control Board
TMDL	Total Maximum Daily Load
UC	University of California
UNFCCC	United Nations Framework on Climate Change Convention
USFS	U.S. Forest Service
USFWS	U.S. Fish & Wildlife Service
USGCRP	U.S. Global Change Research Program
USGS	U.S. Geological Survey
VOC	Volatile Organic Compound
WIEB	Western Interstate Energy Board
WRAP	Western Regional Air Partnership

6.0 References

Abramovitz, J., 1996. *Imperiled Waters, Impoverished Future: The Decline of Freshwater Ecosystems*, Worldwatch Paper 128, Worldwatch Institute, Washington, D.C.

Baker, B., 1994. "Aquatic Systems a Concern as the Government Relicenses Dams," *BioScience* 44, no. 6: 433.

Bay Area Air Quality Management District (BAAQMD), 1998. *Best Available Control Technology (BACT) Guideline*. Bay Area Air Quality Management District, San Francisco, California.

Bernstein, M., R. Lempert, D. Loughran and D. Ortiz, 2000. *The Public Benefit of California's Investments in Energy Efficiency*, MR-1212.0-CEC, RAND Corporation, Santa Monica, California.

California Air Resources Board (CARB), 1999. *The 1999 California Air Quality and Emissions Almanac*. California Air Resources Board, Sacramento, California. See Web Site: arbis.arb.ca.gov/aqd/almanac/almanac99.htm.

California Air Resources Board (CARB), 2000a. *Emissions by Category: 2000 Estimated Annual Average Emissions Statewide*. California Air Resources Board, Sacramento, California. See Web site: www.arb.ca.gov/app/emsinv/emssumcat_query.php?F_DIV=0&F_YR=2000&F_AREA=CA.

California Air Resources Board (CARB), 2000b. *Neighborhood Assessment Program Work Plan*. California Air Resources Board, Sacramento, California. See Web site: arbis.arb.ca.gov/ch/napworkplan.htm.

California Air Resources Board (CARB), 2001. *Strategic Plan for Research 2001-2010, Draft*, California Air Resources Board, Sacramento, California.

California Department of Finance, 2000. *Components of Change in California's Civilian Population as of July 1, 1970 to 1998*. California Department of Finance, Sacramento, California. See Web site: www.dof.ca.gov.

California Department of Fish and Game (CDFG), 2001. "Rare, Threatened, and Endangered Plants List" and "Threatened, and Endangered Animals List" are updated quarterly. See Web site: www.dfg.ca.gov/whdab/html/lists.html.

California Department of Water Resources, 1998. *California Water Plan Update, Bulletin 160-98, Executive Summary*. California Department of Water Resources, Sacramento, California.

California Energy Commission (CEC), 1989. "The Impacts of Global Warming on California – Interim Report," California Energy Commission, Sacramento, California.

California Energy Commission (CEC), 1991. "1991 Global Climate Change: Potential Impacts and Policy Recommendation," California Energy Commission, Sacramento, California.

California Energy Commission (CEC), 1997. "Strategic Plan for Implementing the RD&D Provisions of AB 1890," P500-97-007, California Energy Commission, Sacramento, California.

California Energy Commission (CEC), 1998a. *Executive Summary, 1997 Global Climate Change, Greenhouse Gas Emissions Reduction Strategies for California.* Vol. 1. 500-98-001V1. California Energy Commission, Sacramento, California. See: www.energy.ca.gov/global_climate_change/97GLOBALVOL1.PDF.

California Energy Commission (CEC), 1998b. *1997 Global Climate Change Report: Greenhouse Gas Emissions Reduction Strategies for California, Volume 2*. 500-98-001V2. California Energy Commission, Sacramento, California. See Web site: www.energy.ca.gov/global_climate_change/97GLOBALVOL2.PDF.

California Energy Commission (CEC), 1998c. *1997 Global Climate Change Report: Greenhouse Gas Emissions Reduction Strategies for California, Appendix A: Historical and Forecasted Greenhouse Gas Emissions Inventories for California.* Vol. 3. 500-98-001V3. California Energy Commission, Sacramento, California. See: www.energy.ca.gov/global_climate_change/97GLOBALVOL3.PDF.

California Energy Commission (CEC), 1998d. Fuel Resource Profiles of Electricity Generation and Related CO_2 Emissions for the State of California, California Energy Commission, CEC Staff Report, Sacramento, California.

California Energy Commission (CEC), 2000a. "California Energy Demand, 2000-2010" Staff Report to California Energy Outlook 2000, P200-00-002. California Energy Commission, Sacramento, California.

California Energy Commission (CEC), 2000b. "Public Interest Energy Research: 1999 Annual Report," P500-00-001, California Energy Commission, Sacramento, California.

California Energy Commission (CEC), 2000c. "California's Power Content Label." California Energy Commission, Sacramento, California. See Web Site: www.energy.ca.gov/consumer/power_content_label.html.

California Energy Commission (CEC), 2001a. Five-Year Investment Plan, 2002 Through 2006, P600-01-004a and P600-01-004b, California Energy Commission, Sacramento, California.

California Energy Commission (CEC), 2001b. "Request for Proposal for the Renewables Energy Program Area - RFP 500-00-056," California Energy Commission, Sacramento, California.

California Public Utilities Commission (CPUC), 2000. "California's Electricity Options and Challenges, Report to Governor Gray Davis," San Francisco, California.

Carlin, John, (no date). "Environmental Externalities in Electric Power Markets: Acid Rain, Urban Ozone, and Climate Change." See Web Site: www.eia.doe.gov/cneaf/pubs_html/rea/feature1.html.

Center for Resource Solutions (CRS), 2000. "Green-e Verification Results, 1999." Center for Resource Solutions, San Francisco, California.

Cohen, A. and J. Carlton, 1995. *Nonindigenous Aquatic Species in a United States Estuary: A Case Study of the Biological Invasions of the San Francisco Bay and Delta,* A Report for the U.S.

Fish & Wildlife Service, Washington, D.C. and the National Sea Grant College Program, Connecticut Sea Grant.

Copeland, C, 1997. "Clean Water Act and TMDLs," Congressional Research Service Report 97-831 ENR, Congressional Research Service, Washington, D.C.

Davis, M., 1989. "Lags in Vegetation Response to Greenhouse Warming," *Climatic Change* 15: 75-82.

Dyer, J., 1995. "Assessment of Climatic Warming Using a Model of Forest Species Migration," *Ecological Modeling*. 79: 199-219.

Dunn, S., 2000. *Micropower: The Next Electrical Era*, Worldwatch Paper 151, Worldwatch Institute, Washington, D.C.

Federal Energy Regulatory Commission (FERC), 2000a. "Water Power." See Web Site: www.ferc.fed.us/hydro/docs/waterpwr.htm.

Federal Energy Regulatory Commission (FERC), 2000b. "Project Summary List," Office of Energy Projects, Federal Energy Regulatory Commission, Washington, D.C.

Field, C., G. Daily, F. Davis, S. Gaines, P. Matson, J. Melack, and N. Miller, 1999. *Confronting Climate Change in California: Ecological Impacts on the Golden State*. The Union of Concerned Scientists, Cambridge, MA and Ecological Society of America, Washington, D.C.

Franco, G., 1996. "Staff Report on State and District Air Quality Planning: Trends and Restructuring Implications," California Energy Commission, Sacramento, California.

Franco, G. and J. Loyer, 1997. "Historical and Forecasted GHG Emissions Inventories for California. Emission Inventory: Planning for the Future," in *Proceedings of a Speciality Conference Cosponsored by the Air & Waste Management Association and the U.S. EPA*. October 28-30, 1997.

Franco, G., 2000. "Integration of Air Quality Management Plans into Air Quality Site Specific Analyses for Power Plants," draft report, California Energy Commission, Sacramento, California.

Frederick, K. and P. Gleick, 1999. *Water and Global Climate Change: Potential Impacts on U.S. Water Resources*, Pew Center for Global Climate Change, Arlington, Virginia.

Friends of the River, 1999. *Rivers Reborn: Removing Dams and Restoring Rivers in California*, Special Report, Friends of the River, Sacramento, California.

Gleick, P., 1994. "Water and Energy," *Annual Review of Energy and Environment 19: 267-99.*

Iannucci, J., S. Horgan, J. Eyer, and L. Cibulka, 2000. *Air Pollution Emission Impacts Associated with Economic Market Potential of Distributed Generation in California*, Distributed Utility Associates, Livermore, California.

International Council for Local Environmental Initiatives (ICLEI) U.S. Office, 2000. "Cities for Climate Protection Campaign. U.S. Participants." See Web Site: www2.iclei.org/us/participants.cfm.

Intergovernmental Panel on Climate Change (IPCC), 1995. *Climate Change 1995: IPCC Second Assessment Report*, Cambridge University Press, Cambridge, Massachusetts.

Intergovernmental Panel on Climate Change (IPCC), 2001. *A Report of Working Group I of the Intergovernmental Panel on Climate Change, Summary for Policymakers, IPCC Third Assessment Report*. IPCC Web Site: www.ipcc.ch.

Interlaboratory Working Group (IWG), 1997. *Scenarios of U.S. Carbon Reductions: Potential Impacts on Energy-Efficient and Low-Carbon Technologies by 2010 and Beyond*, LBNL-40533 and ORNL-444, Lawrence Berkeley National Laboratory, Berkeley, California, and Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Jones & Stokes Associates, 1987. *Sliding Toward Extinction: The State of California's Natural Heritage*, 1987, Jones & Stokes Associates, Sacramento, California.

Karl, T., R. Knight, D. Easterling, and R. Quayle, 1995. "Indices of Climate Change for the United States." NOAA/National Climatic Data Center, Asheville, NC. (See figures 2 and 4 in the paper found at www.ncdc.noaa.gov/gcps/papers/icc.html).

King, P., 2001. "If Only Myths Were Megawatts . . .," *Los Angeles Times*, February 7, 2001.

Leavenworth, S. and C. Bowman, 2001. "All Kinds Have Foiled New Plants," *The Sacramento Bee News Capitol Alert*, January 28, 2001. See Web page: www.capitolalert.com/new/old/capalert01_20010128.html.

Legislative Analyst's Office, 1998. "1998 Cal Facts – California's Economy," Legislative Analyst's Office, Sacramento, California.

Lents, J. and J. Allison, 2000. *Can We Have Our Cake and Eat It, Too? Creating Distributed Generation Technology to Improve Air Quality*, University of California, Riverside, California.

Lopez, E., 1999. "Major Demographic Shifts Occurring in California," California Research Bureau, Sacramento, California.

McAllister, D., A. Hamilton, B. Harvey, 1997. "Global Freshwater Biodiversity: Striving for the Integrity of Freshwater Ecosystems," *Sea Wind* 11 (3).

McCully, P., 1996. Silenced Rivers: The Ecology and Politics of Large Dams, Zed Books, London, England.

Morris, G., 2000. *Biomass Energy Production in California: The Case for a Biomass Policy Initiative*, NREL/SR-570-28805, National Renewable Energy Laboratory, Golden, Colorado.

Mount, J., 1995. *California Rivers and Streams*, University of California Press, Berkeley, California.

Nadol, V., 1999. "Aquatic Invasive Species in the Coastal West: An Analysis of State Regulation Within a Federal Framework," *Environmental Law* 29 (2): 339.

Nakicenovic, N. and R. Swart, 2000. Special Report on Emissions Scenarios. Intergovernmental Panel on Climate Change. See IPCC Web page: www.grida.no/climate/ipcc/emission/index.htm.

National Assessment Synthesis Team, 2000. *Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change*, U.S. Global Change Research Program, Washington, D.C. See USGCRP Web page: www.nacc.usgcrp.gov.

National Institute of Environmental Health Sciences (NIEHS), 1999. *NIEHS Report: Health Effects from Exposure to Power-Line Frequency Electric and Magnetic Fields*. NIH Pub. No. 99-4493, Research Triangle, North Carolina.

Natural Resources Defense Council, 2001. "Exposing the Myths of California's Energy Crisis."

Portland, City of, 2000. "Local Action Plan on Global Warming (Draft)," City of Portland, Office of Sustainable Development, Portland, Oregon.

Regulatory Assistance Project, 1999. "Electric Industry Restructuring and the Environment," *Issuesletters*, August 1999. See Web page: www.rapmaine.org/environment.html.

Reilly J. et. al., 1999. "Multi-gas Assessment of the Kyoto Protocol," *Nature* 401, no. 6753 (October 7, 1999): 549–552.

Schipper, L. and J. McMahon, 1995. *Energy Efficiency in California: A Historical Analysis*, American Council for an Energy-Efficient Economy, Washington, DC.

South Coast Air Quality Management District (SCAQMD), 2000. "Southland Has No Stage 1 Episodes for Second Year in Row," *SCAQMD News*, October 27, 2000.

South Coast Air Quality Management District (SCAQMD), 2001. "Board Meeting Date: January 19, 2001, Agenda No. 23," see Web page: www.aqmd.gov/hb/010123a.html.

State and Territorial Air Pollution Program Administrators (STAPPA) and Association of Local Air Pollution Control Officials (ALAPCO), 1999. *Reducing Greenhouse Gases & Air Pollution: A Menu of Harmonized Options*, STAPPA/ALAPCO, Washington, D.C. See Web Site: www.4cleanair.org.

State of Oregon, 2000. "Oregon Carbon Dioxide Emission Standards for New Energy Facilities," see Web Site: www.energy.state.or.us/climate/ccnewst.pdf.

State Water Resources Control Board (SWRCB), 1997. *Strategic Plan*, Sacramento, California.

The Gallup Organization, 2000. "Environment Not Highest-Priority Issue This Election Year," September 25, 2000.

Timmermann A. et al., 1999. "Increased El Niño frequency in a climate model forced by future greenhouse warming," *Nature* 398: 694–697.

UNEP/WMO Information Unit on Climate Change (UNDEP/WMO), 1992. *United Nations Framework Convention on Climate Change*, UNEP/WMO Information Unit on Climate Change, Geneva, Switzerland.

UNFCCC, 1997. "Kyoto Protocol to the United Nations Framework Convention of Climate Change," FCCC/CP/1997/L.7/Add.1, December 10, 1997.

U.S. Department of Energy, Energy Information Administration (USDOE/EIA), 1999. "World Carbon Dioxide Emissions from the Consumption and Flaring of Fossil Fuels, 1990-1999," U.S. Department of Energy, Washington, D.C. See Web Site: www.eia.doe.gov/emeu/iea/tableh1.html.

U.S. Department of Energy, Energy Information Administration (USDOE/EIA), 2000a. *Greenhouse Gases, Global Climate Change, and Energy*. U.S. Department of Energy, Washington, D.C. See Web Site: www.eia.doe.gov/oiaf/1605/ggccebro/chapter1.html.

U.S. Department of Energy, Energy Information Administration (USDOE/EIA), 2000b. *Voluntary Reporting of Greenhouse Gases 1998: Executive Summary*. U.S. Department of Energy, Washington, D.C.

U.S. Department of Energy, Energy Information Administration (USDOE/EIA), 2000c. *Analysis of Strategies for Reducing Multiple Emissions from Power Plants: Sulfur Dioxide, Nitrogen Oxides, and Carbon Dioxide*. U.S. Department of Energy, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 1997. "Fact Sheet: Health and Environmental Effects of Particulate Matter," Office of Air and Radiation and Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 1998. "1997 National Air Quality: Status and Trends," Office of Air and Radiation, U.S. Environmental Protection Agency, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 1999. "Smog—Who Does It Hurt?" EPA-452/K-99-001, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 2000a. "The Quality of Our Nation's Waters: A Summary of the National Water Quality Inventory: 1988 Report to Congress." EPA 841-S-00-001, Office of Water, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 2000b. "Total Maximum Daily Load Program," U.S. Environmental Protection Agency, Washington, D.C. See Web Site: www.epa.gov/region09/water/tmdl.

U.S. Environmental Protection Agency (EPA), 2000c. "Fact Sheet: Proposed Rule for the Location, Design Construction and Capacity Standards for Cooling Water Intake Structures at New Facilities," EPA 821-F-00-008, Office of Water, U.S. Environmental Protection Agency, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 2000d. "Standards Proposed for New Cooling Water Intake Structures to Prevent Large Fish Kills," Press Release, July 21, 2000.

U.S. Environmental Protection Agency (EPA), 2000e. "1998 Toxics Release Inventory Public Data Release," EPA 745-R-00-007, Office Information Analysis and Access, U.S. Environmental Protection Agency, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 2000f. "National Air Quality and Emissions Trends Report, 1998," Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

Venkatram, A. and D. Fitz, 1998. "Measurement and Modeling of PM_{10} and $PM_{2.5}$ Emissions from Paved Roads in California. Phase 1 Final Report." College of Engineering, Center for Environmental Research and Technology, University of California, Riverside, California. See Web Site: www.cert.ucr.edu.

Watson, R., I. Noble, B. Bolin, N. Ravindranath, D. Verardo, and D. Dokken, 2000. *IPCC Special Report on Land Use, Land-Use Change and Forestry*. Cambridge University Press, Cambridge, Massachusetts.

Wilby, R. and M. Dettinger, 1999. "Streamflow Changes in the Sierra Nevada, California, Simulated Using a Statistically Downscaled General Circulation Model Scenario of Climate Change," in S. McLaren and D. Kniveton (eds.), *Linking Climate Change to Land Surface Change*. Kluwer Academic Publishers, Netherlands.

APPENDIX A
PIEREA Projects

APPENDIX B
Environmental Issues

APPENDIX C
Evaluation Criteria

APPENDIX D
Stakeholder Review Group

APPENDIX E
Highlights of the Review of the Draft CEC Staff Report

Appendix A
PIEREA Projects

Appendix A

PIER Environmental Area Projects

Introduction

The California Energy Commission's Public Interest Energy Research (PIER) Program is comprised of six PIER Program funding areas:

1. Residential and Commercial Buildings End-Use Energy Efficiency
2. Industrial / Agricultural / Water End-Use Energy Efficiency (Process Energy)
3. Renewable Energy Technologies
4. Environmentally Preferred Advanced Generation
5. Energy-Related Environmental Research
6. Strategic Energy Research

Energy-Related Environmental Research (otherwise called the PIER Environmental Area, or PIEREA) has been funding projects since the start of the PIER Program. This internal memo briefly describes some of the projects that are currently under way (or will be conducted shortly). Information was obtained from the 1999 PIER Annual Report, Energy Commission work statements and files, and discussions with Energy Commission staff. Each project was reviewed by either the Energy Commission project manager or the contractor project manager.

Each project provides the following information:

1. Background
2. Purpose of project
3. Project participants / funding
4. Public benefits
5. Proposed outcomes
6. Project status
7. Conclusions / recommendations
8. Sources

Table A.1 provides a brief summary of the projects currently being funded in the PIEREA.

Table A.1. Current Projects in the PIER Environmental Area

Project Name	PIER ($000)	Contract Duration	Contractor	Page
Central California Ozone Study	3,000	3/1/00–10/1/03	California Air Resources Board	A-4
Hydropower Operations, Relicensing and Environmental Issues	164	10/15/98–12/31/00 1/1/01-12/31/02	Electric Power Research Institute	A-7
Fish Protection Issues	762	10/15/98–12/31/00 1/1/01-12/31/02	Electric Power Research Institute	A-10
Facilities Water Management	173	10/15/98–12/31/00 1/1/01-12/31/02	Electric Power Research Institute	A-13
Water Quality Criteria and Toxics in Aquatic Environments	224	1/1/00–12/31/00 1/1/01-12/31/02	Electric Power Research Institute	A-16
Emissions Testing and Certification Guidelines for Distributed Generation Generators	90	4/1/00–12/31/00	Electric Power Research Institute	A-19
Degraded or Reclaimed Power Plant Cooling Water	156	3/1/00–12/31/00	Electric Power Research Institute	A-21
Wet, Dry, Hybrid Wet/Dry, and Alternative Cooling	190	3/1/00–12/31/00	Electric Power Research Institute	A-23
Fine and Ultrafine Particulate Study	465	4/15/01-3/15/04	Gas Research Institute	A-25
Golden Eagles in a Perilous Landscape	675	6/24/98–3/31/02	University of California at Santa Cruz	A-28
Assessment of the Costs and Impacts of Global Climate Change	2,159	6/24/98–3/31/02	Electric Power Research Institute	A-30

See PIEREA webpage for descriptions and updates on completed, on-going, and new projects. It is anticipated that this information will be available in early 2002.

PIEREA PROJECT:
Central California Ozone Study
(Contract # 700-98-027)

Background

The San Joaquin and Sacramento Valleys and the surrounding coastal and mountainous regions experience elevated ozone concentrations from June to the early part of September. These concentrations are, in general, higher than the existing State and federal ambient air quality standards. A new, national, more stringent standard for ozone would establish maximum allowed ozone concentrations averaged over an 8-hour period. Even isolated sites far from urban areas experience 8-hour average ozone concentrations higher than the new national standard.

Long-range transport of pollutants, including transport between air basins, plays an important role in these high-ozone events. The current qualitative understanding of long-range transport in this region of California is not adequate for the preparation of air quality management plans designed to bring this region into compliance with State and federal ozone standards. Long-range transport is of importance in the determination of ozone impacts from power plant plumes, because these plumes can reach relatively high elevations and travel long distances, producing impacts in regions far from their release.

The existing photochemical models used for the design of air quality management are technically deficient in their representation of power plant plumes. It is necessary to correct these deficiencies to ensure that power plants and other point sources are correctly modeled. Without such corrections, the degree of air quality improvements forecasted by the existing air quality models and attributable to the control of these point sources may not materialize.

The characterization of emissions from power plant plumes needs to be improved. For example, the actual composition of the volatile organic compounds emitted by power plants in California is not very well known. This information is also important for a better estimation of impacts from power plant plumes.

Finally, the need for improved tools to establish interbasin offset rules have created problems in the licensing of new power plants in California. The results of this research will provide the tools needed to address this problem.

Purpose of Project

The purpose of this project is to participate with the California Air Resources Board (through an Interagency Agreement) in the Central California Ozone Study (CCOS) to gain a better understanding of the dynamics of the existing and expected ozone problem in Central California. The project focuses on developing a better understanding of the contribution of thermal power plant plumes to regional air quality problems in the region of study, and the development of data and methods to ensure the proper treatment of these plumes in the models used to develop air quality management plans. The project will also provide the technical information necessary for the development of interbasin/interpollutant offset rules for the Central California region.

Project Participants/Funding

Contractor: California Air Resources Board (CARB)

CARB Contractor Project Manager: Andrew Ranzieri (916) 324-4069, aranzier@arb.ca.gov

Energy Commission Project Manager: Guido Franco (916) 654-3940, gfranco@energy.state.ca.us

Contract Amount: $3,000,000 (1999)

Contract Term: 3/1/00 – 10/1/03

Other Participants: Several local air districts, EPA, and private entities.

Public Benefits

The results of this study will shape the control strategies to be used in this region of California for at least the next decade. The development of this information and modeling tools will also provide an opportunity to study new ways to use electricity to avoid or reduce air quality problems in this region.

Proposed Outcomes

- Ensure that the appropriate data are collected and analytical models are developed to use in gaining a better understanding of the dynamics of the existing and expected future ozone problem in Central California.
- Develop better understanding of the role of thermal power plant plumes in contributing to regional air quality problems in Central California.
- Develop data and methods needed to ensure the proper treatment of these plumes in models used to develop air quality management plans.

- Develop information that would be used for the development of workable interbasin/interpollutant offset trading rules for the Central California region. Historically, the absence of such rules has caused difficulties in the licensing of new power plants in California.
- Address the problem that regulatory agencies have been reluctant to allow this type of offset trading because of the need for improved technical information, and reduce the regulatory uncertainty for new power plant licensing.

Project Status

Project is on schedule, on budget, and is expected to achieve proposed outcomes. Air quality and meteorological data in the modeling domain are being collected. The Energy Commission is coordinating with the Air Districts to source-test some power plants, and the Air Districts are collecting actual hourly emissions data from all the major sources.

Conclusions/Recommendations

Conclusions and recommendations will be written upon the completion of the project and the PIEREA Research Plan.

Sources

- California Energy Commission. 2000. *Public Interest Energy Research: 1999 Annual Report*. Sacramento, California: California Energy Commission.
- Energy Commission work statement
- Personal communication from Guido Franco, Energy Commission Project Manager, July 27, 2000.

PIEREA PROJECT:
Hydropower Operations, Relicensing and Environmental Issues
(Contract # 100-98-001 #1)

Background

In California, nearly 50 hydropower facilities will be relicensed in the near term, and several dams may be removed (CEC 2000b, pg. 1). The hydroelectricity industry is facing challenges in the relicensing and environmental mitigation areas from the Federal Energy Regulatory Commission (FERC) (CEC 2000a, pg. A-33).

Hydropower facilities affect fisheries through impingement and entrainment of fish in turbines, inhibiting fish passage to spawning habitat, and altering flows and temperatures of extant habitat. Several fish populations in California are now threatened, endangered, or candidates for listing, and resource agencies are studying the need to remove dams or implement mitigation measures to help recover populations (CEC 2000b, pg. 1).

Relicensing efforts will require regulatory agencies to assess a hydropower facility's affects on aquatic and terrestrial ecosystems. To do so, more information is needed to accurately determine site-specific and watershed level impacts from these facilities. Potential decommissioning, or dam removal, will require safe and effective removal and disposal of impoundment sediments that could contain toxic concentrations of contaminants (CEC 2000b, pg. 1).

Balancing the protection of fish and wildlife resources with multiple demands for water use can be optimized by using credible scientific information, tools and methods. The management of hydro project decommissioning, including impoundment (e.g., characterization, removal, and disposal), dam removal, and ecosystem restoration are complex technical issues for which little background science exists.

Purpose of Project

The purpose of this project is to address the issues involved in relicensing and environmental mitigation. This project: (1) investigates best practices for relicensing and mitigation; (2) identifies research and development needs; (3) identifies flows and cost-effective designs to improve fish passage and reduce mortality; and (4) summarizes background information and issues of concern regarding decommissioning (e.g., dam removal and ecosystem restoration) and sediment disposal.

Project Participants/Funding

Contractor: Electric Power Research Institute (EPRI)

EPRI Contractor Project Manager: Doug Dixon (804) 642-1025 ddixon@epri.com

Energy Commission Project Manager: Linda Spiegel (916) 654-4703 lspiegel@energy.state.ca.us

Contract Amount: $89,250 (1999), $28,000 (2000), and $46,125 (2001); Total is $164,175

Contract Term: 10/15/98 – 12/31/00, 1/1/01-12/31/02

Other Participants: B.C. Hydro International Ltd.; HCI Publications; Iris Power Engineering Inc.; Kearns & West, Inc.; EA Engineering; Science & Technology; Lang, Railsback & Associates; Lockheed Martin Energy Research Corp

Public Benefits

The management of hydro project relicensing, decommissioning, and mitigating environmental issues is complex and requires current, state-of-the-art scientific studies and information sharing to proceed. The primary benefit of this project is the design and production of new data and tools to help ensure that decision-makers have the information necessary to balance competing issues and interests in regulatory proceedings involving these facilities.

At a low cost, this project provides information using studies and forums from worldwide expertise that might otherwise be unavailable, so that regulatory agencies can make informed decisions during siting and relicensing processes. Other public agencies in California that will benefit from these reports, the Web Site, and forum proceedings include the Department of Fish and Game, Department of Water Resources, and Regional Water Quality Control Boards. Additionally, federal agencies such as U.S. Fish & Wildlife Service and the U.S. Bureau of Reclamation, which deal with California hydro relicensing and decommissioning issues, will also benefit (CEC 2000b, pg. 4).

Proposed Outcomes

- Improve the relicensing process to achieve results acceptable to all stakeholders at minimum cost to stakeholders by providing information on relicensing best practices for the hydropower industry. Examples: a Best Practices Guidebook for the hydropower industry, a Web Site on hydropower research and relicensing, and technical reports.

- Reduce the cost of operating hydropower while protecting the environment by providing information on worldwide technological developments relevant to the hydropower business. Examples: semi-annual reports and technical reports.
- Improve fish protection methods by providing scientific information, techniques, and guidance based on state-of-the-art and emerging methods for instream flow management. Example: technical reports.
- Decrease fish mortality by providing assessment methods for more accurately evaluating the effects of turbine entrainment and mortality on fish populations. Example: technical reports.
- Provide information and tools for determining cost-effective upstream and downstream fish passage and protection needs for migratory and nonmigratory fish. Examples: technical reports and international conference / workshop.
- Improve water resources management for optimized power production while complying with environmental protection requirements. Examples: technical reports and research-grade software.
- Offer a cost-effective approach for site-specific environmental data gathering and ecosystem research needs, while providing future communication links with the environmental management, regulatory, and research community. Example: graduate research fellowships.

Project Status

Project is on schedule, on budget, and is expected to achieve proposed outcomes.

Conclusions/Recommendations

Conclusions and recommendations will be written upon the completion of the project and the PIEREA Research Plan.

Sources

- California Energy Commission (CEC). 2000a. *Midterm Report: PIER Environmental Subject Area, Hydropower Relicensing Environmental Issue, Target 87.0 & 87.1 1999, Target 48 2000.* Sacramento, California: California Energy Commission.
- California Energy Commission (CEC). 2000b. *Public Interest Energy Research: 1999 Annual Report*. Sacramento, California: California Energy Commission.
- Personal communication from Linda Spiegel, Energy Commission Project Manager, July 24, 2000.

PIEREA PROJECT:
Fish Protection Issues
(Contract # 100-98-001 #1)

Background

The protection of aquatic species communities is a primary focus of water permitting for power plants and industrial facilities under the Clean Water Act (CWA), sections 316 (a) and (b). Section 316 (a) of the CWA addresses heated cooling water discharges, and Section 316 (b) of the CWA addresses entrainment into intakes and impingement on intake screens (CEC 2000b, pg. A-37). Variances previously granted to requirements of Sections 316 (a) of the CWA may be disallowed in the future, potentially affecting 10–15 power plants in California. Therefore, some of the existing plants that apply for repowering permits may not be able to get a variance after an assessment shows that the thermal discharge allowed by earlier permits may in fact be unacceptable by today's standards. Section 316 (b) of the CWA is currently under review by the EPA. New rules could result, requiring existing facilities to replace or modify cooling system intakes based on new definitions of "Adverse Environmental Impact" and "Best Technology Available" (CEC 2000a, pg. 1).

Energy facilities utilizing cooling waters that support fish and other aquatic biota can affect these organisms by killing or injuring them while: (1) entraining them in abnormally hot water that is transported through the heat exchange piping system; (2) exposing organisms in the receiving waters to heated discharges associated with once-through cooling systems; or (3) by impinging these aquatic organisms on intake screens (CEC 2000a, pg. 1).

Purpose of Project

The purpose of this project is to develop practical design and operational measures to protect aquatic species communities likely to be affected by power plants and other industrial facilities that use water from lakes, rivers, and other large water bodies for cooling purposes (CEC 2000a, pg. 1). The results will be used to address biological community and biodiversity risks associated with power plant and industrial facilities operations.

The research and development effort that is expected to be accomplished within this project will help further our understanding of the biology of potentially affected aquatic organisms and the susceptibility of these organisms to the stresses caused by the facilities using water for cooling. Subsequently, the need and extent for changes in methods to mitigate identified impacts can be determined and implemented in the best-cost way to meet regulatory requirements (CEC 2000a, pg. 1).

Project Participants/Funding

Contractor: Electric Power Research Institute (EPRI)

EPRI Contractor Project Manager: Doug Dixon (804) 642-1025 ddixon@epri.com

Energy Commission Project Manager: Linda Spiegel (916) 654-4703 lspiegel@energy.state.ca.us

Contract Amount: $262,700 (1999), $262,700 (2000), and $236,395 (2001); Total is $761,795

Contract Term: 10/15/98-12/31/00, 1/1/01-12/31/02

Other Participants: Alden Research Laboratory Inc; Applied Biomathematics Inc; Duke Energy Corporation; EA Engineering, Science & Technology; Langhei Ecology LLC; Lockheed Martin Energy Systems Inc; Tennessee Valley Authority; Tetra Tech Inc

Public Benefits

The type of information developed through this project is critical to an understanding of biological impacts and, therefore, to regulatory decision making. This project provides information using studies and forums from worldwide expertise that may otherwise be unavailable to regulatory agencies to make informed decisions during siting and relicensing processes. Other public agencies in California that will benefit from these reports, Web Site, and forum proceedings include Department of Fish and Game, Department of Water Resources, and Regional Water Quality Control Boards.

In addition to the need for this information in regulatory proceedings, compliance with Section 316 (a) and (b) regulations is essential for facilities to effectively operate in California's energy enterprise market as it currently exists. Otherwise, the threat of costly fines and penalties could cause some producers to fall out of the competitive mix. If this project meets its objectives, energy facilities using cooling waters will likely be able to reduce the cost of regulatory compliance, because the information and models developed could reduce the size and extent of in-field species and habitat monitoring required prior to receiving a construction permit (CEC 2000a, pg. 3).

Proposed Outcomes

- Provide California with effective "best technology available" (BTA) engineering methods for cooling system intakes. Examples: database and reports.
- Provide objective science and engineering to the California energy debate on water use impacts. Examples: workshops and conferences.
- Develop accurate ecological risk assessment tools to assess the effects of power plant operation on individual fish and the risk to aquatic communities for cost-effective fish protection options.

Project Status

Project is on schedule, on budget, and is expected to achieve proposed outcomes.

Conclusions/Recommendations

Conclusions and recommendations will be written upon the completion of the project and the PIEREA Research Plan.

Sources

- California Energy Commission (CEC). 2000a. *Public Interest Energy Research: 1999 Annual Report*. Sacramento, California: California Energy Commission.
- California Energy Commission (CEC). 2000b. *PIER Environmental Subject Area, 316(a) & (b), Fish Protection Issues, Target 103 1999, Target 44 2000.* Sacramento, California: California Energy Commission.
- Personal communication from Linda Spiegel, Energy Commission Project Manager, July 21, 2000.

PIEREA PROJECT:
Facilities Water Management
(Contract # 100-98-001 #1)

Background

In California, power plants are faced with the competing demands of reducing fresh water consumption (through either water conservation measures or the use of degraded water supplies), while at the same time having to meet more stringent wastewater discharge standards. A 500-MW gas-fired combined-cycle power plant using wet-cooling technology may require from 2,000 acre-feet per year to more than 3,500 acre-feet per year, depending on the quality of the water. There are currently 9,023 MW of gas-fired generation in the Energy Commission's siting process with more than 7,000 MW in applications expected to be filed in the near future. Strategies under development to reduce power plant water consumption are broadly applicable to other types of heavy industry.

More stringent water quality standards are currently being developed for California by the State and federal government. Over 300 hundred water bodies in California have been identified by the federal and State governments as impaired (i.e., the quality of these water bodies is not suitable for the designated uses that have been identified for them). Therefore, future regulations are likely to place stricter limitations on the quality of wastewater discharges from power plants and other types of heavy industry.

The competing demands for reducing freshwater use and meeting higher wastewater quality criteria create a dilemma for power plant facilities. For example, power plants using cooling towers can reduce water demand by increasing the number of cycles the water is run through the cooling tower. Although additional cycles can significantly reduce a project's water demand, it also concentrates the inorganic constituents originally found in the source water (which is similar to the problem of handling high-saline drain water from agriculture). The greater the number of cycles, the greater the concentration of inorganics, and the greater the difficulty in meeting water quality standards for power plants trying to minimize water consumption. In California, the federal and State governments are in the process of adopting new water quality standards and implementation procedures that may make it difficult for new facilities to comply without new water management practices (CEC 2000b, pg. 1).

Purpose of Project

The purpose of this project is to develop and implement cost-effective strategies for controlling biofouling, treating wastewater, and treating and recycling cooling water while maintaining minimal impact on the environment. This project will focus on strategies that include reducing biocide discharges, removing heavy metals, minimizing nitrogen compounds to reduce eutrophication (an aquatic environment wherein plant life

is favored over animal life) of water resources, and reducing bioaccumulative pollutants from plant wastewater (CEC 2000a, pg. A-38).

Project Participants/Funding

Contractor: Electric Power Research Institute (EPRI)

EPRI Contractor Project Manager: Rich Carlton (650) 855-2115 rcarlton@epri.com

Energy Commission Project Manager: Joe O'Hagan (916) 653-1651 johagan@energy.state.ca.us

Contract Amount: $55,200 (1999), $55,200 (2000), and $62,196 (2001); Total is $172,596

Contract Term: 10/15/98-12/31/00, 1/1/01-12/31/02

Other Participants: Di Filippo Michael; Lytle Mel C; Alabama Power Company; Betz Dearborn, Inc.; Gannett Fleming, Inc.; Puckorius & Associates, Inc.; University of California, Berkeley; University of Iowa; University of Southern California; Water Systems Specialists, Inc.

Public Benefits

The public benefit of this project is in identifying strategies for reducing water consumption, therefore providing new water supplies for other, higher uses. The focus of these efforts is the development of treatment processes and alternative biocides applicable to power plants and other types of heavy industry. Although the water demand for these facilities may not be significant on a statewide or regional basis, they may have significant effects locally. With the development of this information, alternative measures can be provided to applicants for new and existing facilities and be shared with other water agencies (CEC 2000b, pg. 2).

Proposed Outcomes

- Provide biofouling control and plant performance strategies. Examples include guidelines, development of alternative nontoxic biocides, and field studies and demonstrations.
- Provide cost-effective wastewater treatment strategies. Examples include guidelines and development of alternative wastewater treatment technologies.
- Provide cooling water treatment and reuse strategies. Examples include guidelines, development of cooling water treatment tools, and research studies.

Project Status

Project is on schedule, on budget, and is expected to achieve proposed outcomes.

Conclusions/Recommendations

Conclusions and recommendations will be written upon the completion of the project and the PIEREA Research Plan.

Sources

- California Energy Commission (CEC). 2000a. *PIER Environmental Subject Area, Facility Water Management, Target 105 1999, Target 46 2000.* Sacramento, California: California Energy Commission.
- California Energy Commission (CEC). 2000b. *Public Interest Energy Research: 1999 Annual Report*. Sacramento, California: California Energy Commission.
- Personal communication from Joe O'Hagan, Energy Commission Project Manager, July 27, 2000.

PIEREA PROJECT:
Water Quality Criteria and Toxics in Aquatic Environments
(Contract # 100-98-001 #1)

Background

Metals, such as selenium, arsenic, mercury, and copper represent a major source of water quality degradation throughout California. These trace elements generally are not very soluble in water and can be toxic to aquatic organisms in minute amounts. Depending on the concentration of the metal, impacts to aquatic organisms range from arrested development to mortality. Certain metals, such as mercury and selenium, accumulate in the tissue of aquatic organisms over time and can be passed up the aquatic food chain (bioaccumulation).

It is not only the amount of a metal within a water body that can adversely effect aquatic organisms. Water conditions, such as pH and hardness, influence the amount or bioavailability of the metal to aquatic organisms. Metals may also form complexes with organic molecules or become attached to clay particles. Furthermore, the presence of several metals within a water body can have a synergistic effect, increasing the metal's toxicity. Currently, water quality criteria for metals are based upon the total concentration of the metal. However, the total concentration may not represent a real value that is actually biologically available to aquatic organisms. Revised water quality criteria should take into account a concentration, or an estimate of the proportion, that would be biologically available to various aquatic organisms.

There is currently 9,023 MW of gas-fired generation in the siting process, with more than 7,000 MW in applications expected to be filed in the near future. This new generation may introduce significant amounts of metals into water bodies. Relatively low ambient levels of metals within the source water for power plants using wet-cooling technology can become highly concentrated through several cooling cycles, raising significant wastewater discharge issues. Because of these concerns, the project designs of several recently proposed power plant projects had to be significantly changed, late within the certification process (CEC 2000 a, pg. 1).

Purpose of Project

The purpose of this project is to provide the Energy Commission and other State agencies mandated to protect water quality and aquatic resources the latest information on evaluating potential impacts from metal-bearing discharges, as well as information useful in determining appropriate power plant project designs (CEC 2000 a, pg. 1).

Project Participants/Funding

Contractor: Electric Power Research Institute (EPRI)

EPRI Contractor Project Manager: Rick Carlton (650) 855-2115 rcarlton@epri.com

Energy Commission Project Manager: Joe O'Hagan (916) 653-1651 johagan@energy.state.ca.us
Contract Amount: $120,000 (2000) and $103,525 (2001); Total is $223,525
Contract Term: 1/1/00-12/31/00, 1/1/01-12/31/02

Other Participants: California Department of Water Resources

Public Benefits

The source water for power plants can have low to high levels of metals. Typical water use by a 500-MW fossil-fueled power plant is about 2–3 million gallons per day. To conserve water, it is desirable to use degraded water and/or to incorporate a recirculating closed-loop system. Both of these result in elevated concentrations of metals in the wastewater. Therefore, the toxicity of cooling tower drift and/or wastewater streams is an environmental concern. The reports and models provided in this project will help regulators determine the effects of these toxics on the aquatic ecosystems and develop appropriate mitigation measures.

Products developed in this project will allow regulatory agencies to accurately model the transport and fate of certain metals cycling through an aquatic ecosystem. This modeling will provide a sound basis for the site-specific permitting of selenium or mercury discharges. Other products will provide information on better methodologies for estimating the amount of bioaccumulation that is likely to occur and, therefore, also for guiding site-specific permitting of wastewater discharges. Information resulting from this project will be shared with other interested agencies, such as the State Water Resources Control Board, the Regional Water Quality Control Boards, and the Department of Fish and Game (CEC 2000a, pg. 1).

Proposed Outcomes

- Improve models that quantify factors that affect mercury flows, pool sizes, and biological availability to aquatic food webs.
- Develop field methods for measuring bioaccumulation (the uptake and accumulation of chemicals from water, soils, or through diet).
- Develop models for assessing metal toxicity for site-specific uses. Examples include guidelines.
- Assess and synthesize research on contaminated sediment and of field studies on releases of sediment-bound chemicals associated with utility operations.

- Conduct case studies to validate the current model for determining chemical discharges to rivers from pipes, submerged diffusers, groundwater seepage, and atmospheric deposition.
- Develop a human health risk model for toxics.
- Evaluate and possibly improve EPA methodology for establishing biological criteria and bioassessment techniques.

Project Status

Project is on schedule, on budget, and is expected to achieve proposed outcomes.

Conclusions/Recommendations

Conclusions and recommendations will be written upon the completion of the project and the PIEREA Research Plan.

Sources

- California Energy Commission (CEC). 2000. *PIER Environmental Subject Area, Water Quality Criteria and Toxics in Aquatic Environments, Target 43 2000.* Sacramento, California: California Energy Commission.
- Personal communication from Joe O'Hagan, Energy Commission Contract Manager, July 27, 2000.

PIEREA PROJECT:
Emissions Testing and Certification Guidelines for Distributed Generation Generators
(Contract # 100-98-001)

Background

The potential proliferation of small distributed generators (DG) in California could unnecessarily overload the current permitting process. Many DGs will be of the same make and model, begging the question, "Why test every model of the same nameplate, when their emissions will be nearly the identical?" This project was formed to answer this question.

Purpose of Project

The purpose of this project is to reduce the cost and time for distributed electricity generation technologies (typically, small combustion turbines, fuel cells, and internal combustion engines) to meet existing and anticipated future emission regulations. This project consists of a scoping study to establish test parameters, prepare a test plan, and coordinate with appropriate State and local air pollution control authority. Recommendations will be designed to establish factory certification based upon random testing, rather than for every machine. Hence, the project will advance the technology of statistical sampling for certification purposes, in order to accelerate the development of these technologies.

Project Participants/Funding

Contractor: Electric Power Research Institute (EPRI)

EPRI Contractor Project Manager: Brice Freeman (650) 855-1050 bfreeman@epri.com

Energy Commission Project Manager: Matt Layton (916) 654-3868 mlayton@energy.state.ca.us

Contract Amount: $89,700 (1999)

Contract Term: 4/1/2000 - 12/31/2000

Other Participants: None

Public Benefits

This project supports the goal of PIER's Environmentally Preferred Advanced Generation and Strategic areas for increasing and accelerating the advancement and deployment of distributed electricity-generating devices. With the assistance of EPRI, the California Energy Commission—in cooperation with CARB, the California Air Pollution Control Officers Association (CAPCOA), and local air pollution control districts—would establish acceptable emission certification protocol for distributed generators (typically small combustion turbines, fuel cells, and internal combustion engines). This project will advance the technology of statistical sampling for certification purposes, recognizing the (to be determined) performance variability within product line. The ultimate goal is to accelerate the deployment of these promising technologies.

Proposed Outcomes

- Identification and classification of distributed generators currently under production and those that show promise of production in the near future.
- Assessment of emissions and comparison of emissions to the limits set and anticipated to be set by California's Air Pollution Control Districts.
- Testing protocol for any distributed generators applying for "fleet" certification in the State.
- Criteria for a quality emissions testing and certification center, and comparison and ranking of major California facilities against this criteria set.

Project Status

This project is almost complete. A final report will be submitted on December 31, 2000.

Conclusions/Recommendations

Conclusions and recommendations will be written upon the completion of the project and the PIEREA Research Plan.

Sources

- Energy Commission work statement
- Personal communication from Brice Freeman, EPRI Project Manager, July 28, 2000.

PIEREA PROJECT:
Degraded or Reclaimed Power Plant Cooling Water
(Contract # 100-98-001)

Background

In California and throughout the world, competing demands for fresh water, environmental health and safety concerns, and aesthetic issues have forced thermal power plants to consider alternative cooling water supplies. Currently, there are limited alternative water supplies for power plants. Thermal power plants reject heat to a body of water or the atmosphere during the production of electricity. Evaporative cooling towers are the most common cooling method and use significant quantities of water. Alternative water supplies offer opportunities for power plants to limit their impacts on local water supplies. However, there are uncertainties regarding the costs and environmental impacts of using unprocessed, degraded cooling water, and about the availability of degraded or reclaimed cooling water supplies.[1]

Purpose of Project

This project will identify current and potential research that can define and improve the relative costs and environmental impacts of the use of untreated degraded or reclaimed water.

The purposes of this project are: (1) Identification of potential types of pollutants commonly found in contaminated water sources that can be used for power plant cooling; (2) investigation of the feasibility of using degraded or reclaimed water for power plant cooling without pre-treatment; and (3) identification and/or development of effective treatment programs for the systems where degraded or reclaimed water will be used.

Project Participants/Funding

Contractor: Electric Power Research Institute (EPRI)

EPRI Contractor Project Manager: Rick Carlton (650) 855-2115 rcarlton@epri.com

Energy Commission Project Manager: Joe O'Hagan (916) 653-1651 johagan@energy.state.ca.us

Contract Amount: $155,974 (1999)

Contract Term: 3/1/00 – 12/31/00

Other Participants: None currently

[1] *Degraded water* refers to surface or groundwater sources not suitable for most uses because of natural or anthropogenic contamination. Degraded water includes reclaimed or recycled water.

Public Benefits

This project could provide opportunities to conserve scarce California water resources for environmental protection purposes and for improving the energy cost and value of California's electricity. If the more than 22,000 MW of projected new and replacement electricity generation in California used degraded or reclaimed cooling water, approximately 140,000 acre-feet per year of fresh water could be used for other purposes. However, uncertainties regarding the environmental benefits and costs of using degraded or reclaimed water in wet cooling towers without processing may limit their broader penetration into the California generation sector. The analyses resulting from this project will provide decision makers an understanding of when and where it would be appropriate to use degraded and reclaimed water, and the environmental tradeoff and costs associated with their use.

Proposed Outcomes

- Potential types of pollutants commonly found in contaminated water sources that can be used for power plant cooling.
- Feasibility of using degraded or reclaimed water for power plant cooling without pre-treatment.
- Effective treatment programs for the systems where degraded or reclaimed water will be used.

Project Status

Project is on schedule, on budget, and is expected to achieve proposed outcomes.

Conclusions/Recommendations

Conclusions and recommendations will be written upon the completion of the project and the PIEREA Research Plan.

Sources

- California Energy Commission (CEC). 2000. Work Authorization for Degraded Water Tailored Collaborative. March 30, 2000.
- Personal communication from Joe O'Hagan, Energy Commission Project Manager, July 27, 2000.

PIEREA PROJECT:
Wet, Dry, Hybrid Wet/Dry, and Alternative Cooling Technologies for Thermal Power Plants
(Contract # 100-98-001)

Background

In California and throughout the world, competing demands for fresh water, environmental health and safety concerns, and aesthetic issues have forced thermal power plants to consider alternative cooling schemes. Thermal power plants reject heat to a body of water or the atmosphere during the production of electricity. Wet, or evaporative, cooling towers are the most common cooling method. Dry or hybrid (a combination of wet and dry heat rejection mechanisms) cooling towers are technically feasible, and can reduce water use and certain environmental impacts. However, there are significant uncertainties regarding the environmental benefits, costs, and performance penalties associated with these dry cooling technologies, as compared to wet cooling towers.

Purpose of Project

The purposes of this project are as follows:

- Define and compare the current costs and performance of the dry and hybrid wet/dry cooling towers, relative to wet cooling towers.
- Identify the environmental benefits and trade-offs between wet, dry, and hybrid wet/dry cooling towers.
- Identify future research that can improve the costs and performance of wet, dry, and hybrid wet/dry cooling towers.
- Identify any other alternative power plant cooling technologies that can improve the environmental and public health costs/risks of California's electricity.

Project Participants/Funding

Contractor: Electric Power Research Institute (EPRI)

EPRI Contractor Project Manager: Kent Zammit (650) 855-2097 kezammit@epri.com

Energy Commission Project Manager: Matt Layton (916) 654-3868 mlayton@energy.state.ca.us

Contract Amount: $190,435 (1999)

Contract Term: 3/1/00 – 12/31/00

Other Participants: Cooling Technology Institute

Public Benefits

Dry and hybrid wet/dry power plant cooling technologies can reduce water consumption by as much as 90 percent, compared to current best practices (wet cooling towers). If the more than 22,000 MW of projected new and replacement electricity generation for California used dry cooling, approximately 140,000 acre-feet per year of fresh water could be used for other purposes. However, the current relative costs and performance of dry and hybrid wet/dry cooling technologies are uncertain—and possibly negative, compared to wet cooling towers, which would limit their broader penetration into the California generation sector.

Proposed Outcomes

- Current costs and performance of wet, dry, and hybrid wet/dry cooling technologies.
- Environmental benefits and trade-offs between wet, dry, and hybrid wet/dry cooling towers.
- Research that can improve the costs and performance of wet, dry, and hybrid wet/dry cooling technologies.
- Alternative power plant cooling technologies that might improve the environmental and public health costs/risks of power plant cooling for California's electricity.

Project Status

EPRI has completed the initial review of known installations of dry and hybrid cooling technologies. Current efforts center on the development of the four reference site studies comparing the costs, benefits, and O&M impacts of alternative cooling systems. Final report should be available for peer review by December 31, 2000.

Conclusions/Recommendations

Conclusions and recommendations will be written upon the completion of the project and the PIEREA Research Plan.

Sources

- Energy Commission work statement.
- Personal communication from Kent Zammit, EPRI Project Manager, July 26, 2000.

PIEREA PROJECT:
Fine and Ultrafine Particulate Study
(Contract # [TBA])

Background

Epidemiological and animals studies have found an association between the concentration of Particulate Matter (PM) in ambient air and morbidity (illnesses) and mortality. Recent epidemiological studies have found that fine particles (particles less than 2.5 microns) are better correlated with detrimental health effects than the larger particles. Although the mechanisms for these effects are not known, a leading hypothesis is that the causative agent is ultra-fine particles (particles less than 0.1 micron) or particular chemical compounds produced or released from combustion processes.

Since available fine / ultrafine particulate emissions data are very limited, additional efforts are required to develop realistic mass emission rates and ultrafine emission counts and the corresponding source emissions profiles that will serve as a basis for scientifically sound emission inventories and future regulations. Existing regulatory testing method for stationary combustion sources are known to inaccurately characterize the mass and composition of PM emissions from these sources.

PM source test data for gas turbines, obtained using existing regulatory testing methods, show a wide variation of results. Available data indicate that more than 75 percent of the PM emissions from gas turbines are condensables that are not captured on filters used in the sampling trains. Chemical analyses of condensables show that they are mostly inorganic materials. There are some concerns that the existing test method may be responsible for the artificial production of inorganic condensable material, which may explain, at least in part, the wide variation in emission rates measured even for the same type of gas turbine. For this reason, power plant developers, in most cases, feel obligated to overestimate anticipated PM emissions to avoid the potential for compliance issues once the power plants begin operation. PM emissions from power plants is the most difficult air quality siting issue because of public concern with this pollutant, and the lack of sufficient PM offsets in most air basins in California.

Purpose of Project

The purpose of this project is to develop a more accurate and precise particulate matter (PM) reference test method for measuring PM emissions from combustion sources, including natural-gas-fired turbines.

The research program sponsored through this program will develop methods or enhance existing methods, as needed, to measure fine (PM less than 2.5 microns) and ultrafine (PM less than 0.1 micron) particulates, and PM_{10} (particulate less than 10 microns). The research includes the testing of the new source test method(s) in several full-scale power-generation-related combustion sources and other sources. Other major goals of this project include:

- Develop technically sound hypotheses to explain variability in the PM source test results for gas turbines. Demonstrate the validity of these hypotheses by conducting PM source tests in existing power plants using the new PM source test methods developed in this research program.

- Generate sufficient technical data to allow adoption and certification of the developed methods by the California Air Resources Board and the Environmental Protection Agency.

Project Participants/Funding

Contractor: Gas Research Institute (GRI)

GRI Contractor Project Manager: Jim McCarthy (773) 399-8174 jmccarthy@gri.org

Energy Commission Project Manager: Guido Franco (916) 654-3940 gfranco@energy.state.ca.us

Contract Amount: $465,000 (1999)
Contract Term: 4/15/01-3/15/04

Other Participants: tba

Public Benefits

The test method(s) developed under this project have the potential to significantly influence future mitigation strategies in California and to better characterize the risk posed by combustion gas turbines for future projects before the California Energy Commission in its power plant licensing program.

Proposed Outcomes

- Documentation of the "state of the art" in PM testing by conducting a comprehensive literature review and a survey of research institutions and relevant regulatory agencies
- Method to collect and preserve adequate samples for chemical analyses of their chemical constituents.
- Method to produce accurate results with a ±1 percent when tested with gases with known PM concentrations.
- Method to capture 99 percent of the particles segregated by size as ultrafine, fine, and PM_{10}.
- Complete emission profiles (speciated PM, speciated VOCs, NO_X, NO, NO_2) for a minimum of four combustion sources used in power generation, including gas turbines.

Project Status

Not in place.

Conclusions/Recommendations

Conclusions and recommendations will be written upon the completion of the project and the PIEREA Research Plan.

Sources

- Energy Commission work statement.
- Personal communication from Guido Franco, Energy Commission Contract Manager, July 27, 2000.

PIEREA PROJECT:
Golden Eagles in a Perilous Landscape: Tracking the Effects of Mitigation for Energy-Based Mortality
(Contract # 500-97-036)

Background

The golden eagle is a protected species, and unless research demonstrates that the population is stable, or appropriate mitigation is developed, the development of new energy supplies that possibly endanger golden eagles may be in jeopardy. In the Altamont Pass Wind Resource Area (WRA), an estimated 40–60 golden eagles and several hundred red-tailed hawks are killed annually by collisions with wind turbines. Electrocution is another source of golden eagle fatality, both within and outside the WRA. These fatalities are a concern for stakeholders and produce costly permitting delays.

Purpose of Project

The purpose of this project is to assist in understanding the complex interactions of golden eagles with the electrical power producing Altamont Pass WRA structures. The methodology involves monitoring radio-tagged golden eagles to determine the interactions with the wind turbines, and effects of that interaction on the long-term viability of the population.

Project Participants/Funding

Contractor: University of California at Santa Cruz

Contractor Project Manager: Grainger Hunt (530) 336-7281 grainger@cats.ucsc.edu

CEC Project Manager: Dick Anderson (916) 654-4166 danderso@energy.state.ca.us

Contract Amount: $675,121

Contract Term: 6/24/98 – 3/31/02

Other Participants: H. Peters Consulting

Public Benefits

This project will provide information that will lead to the reduction of golden eagle fatalities from interactions with wind turbines. The results will also help resolve collision issues between wind turbines and other raptor species.

Proposed Outcomes

- Provide information focusing on whether the WRA-wide golden eagle population is stable, increasing in size, or declining in size.

- Determine whether there is a correlation between golden eagle use of the WRA and ground squirrel concentrations.
- Determine whether ground squirrel concentrations are attracting golden eagles into risky situations.
- Document golden eagle use of the following areas: (1) where recent structural modifications have been made; (2) where wind turbines in high-risk areas have been removed; and (3) where there has been repowering of some areas with new, larger, more-efficient wind turbines.
- Improve public perception of wind power.

Project Status

Project is on schedule, on budget and is expected to achieve proposed outcomes.

Conclusions/Recommendations

Conclusions and recommendations will be written upon the completion of the project and the PIEREA Research Plan.

Sources

- California Energy Commission (CEC). 2000a. *Public Interest Energy Research: 1999 Annual Report*. Sacramento, California: California Energy Commission.
- Personal communication from Dick Anderson, CEC Project Manager, December 12, 2000.

PIEREA PROJECT:
Assessment of the Costs and Impacts of Global Climate Change
(Contract # 500-97-043)

Background

The increased need for electricity in California is spurring development of new electricity generation facilities. Because this fleet of generating units will serve the State for 30 or more years, it is important now to predict the impacts of global climate change on the ability of these facilities to operate. Improved regional circulation models will enable researchers to evaluate the effects of global climate change on California and its electricity generating system. Planners in particular will benefit from predictions of potential climatic effects on the system. Modeling will continue to be the primary tool for evaluating the possible impacts of climate change. Improved regional circulation models will be complex, expensive, and time-consuming to run. However, if accurate models were to be developed, they could be used by regulators and generation planners to incorporate GHG considerations into licensing, planning, and regulatory decisions.

Purpose of Project

The purpose of this project is to study the phenomenon of climate change, and from the understanding gained, provide information necessary to evaluate the best options for addressing the impacts of climate change in the United States, including a focus on California. This project will improve our understanding of the physical impacts of global climate change in California.

This project will provide insights into potential climate change impacts in California on market systems, such as potential changes in agricultural outputs, water resources, energy consumption, and hydroelectric power production. This will all be accomplished using an integrated framework that will allow for the study of potential adaptation options. Using steady-state and transient climatic scenarios, this project will also provide a more detailed and complete analysis of the potential shifts in vegetation throughout the end of this century than that available in the technical literature today. Finally, this project will also identify potential adaptation measures to address the expected climate impacts.

Project Participants/Funding

Contractor: Electric Power Research Institute (EPRI)

EPRI Contractor Project Manager: Richard Richels (650) 855-2602 rrichels@epri.com

CEC Project Manager: Guido Franco (916) 654-3940 gfranco@energy.state.ca.us

Contract Amount: $2,159,000

Contract Term: 6/24/98 - 3/31/02

Other Participants: Stratus Consulting, Exponent Health Group, Yale University, Stanford University, U.C. Davis, MIT, University of Colorado, and Oregon State University

Public Benefits

Global climate change has the potential to significantly affect virtually all sectors of the economy in California. Energy consumption and electricity production in particular may be severely affected by a changing climate. For example, higher temperatures would affect demand through higher air conditioner loads and a smaller snowpack could reduce availability of hydroelectric resources. Currently, hydroelectric is the least expensive source of electricity and accounts for 25 percent California's electricity supply. If these resources are not available, the demand for electricity will need to be supplied through the use of other fuels and technologies. Thus, there is a strong need to plan for the future, taking into account the issues and options offered by a changing climate. This project will provide a strong foundation for a larger research program addressing this strategic opportunity.

Proposed Outcomes

- Assess the potential costs and implications to California of global climate change.
- Reduce the uncertainty in, and improve the performance of, general circulation and carbon-cycle models used to predict climate change effects.
- Study the potential effects of climate change on human health, economic activities, and natural ecosystems.
- Evaluate regional impacts of possible climate changes, including potential effects in California on agriculture, forestry, and water resources.
- Enhance an integrated assessment framework and use it to examine alternative proposals for reducing GHG emissions in terms of costs and benefits.

Project Status

The project is on schedule, on budget and is expected to achieve proposed outcomes.

Conclusions/Recommendations

Conclusions and recommendations will be written upon the completion of the project and the PIEREA Research Plan.

Sources

1. California Energy Commission (CEC). 2000a. *Public Interest Energy Research: 1999 Annual Report*. Sacramento, California: California Energy Commission.
2. Personal communication from Guido Franco, CEC Project Manager, December 11, 2000.

Appendix B
Environmental Issues

Appendix B

Lower-Priority Environmental Issues

As mentioned in Section 1, the following issues were considered in the initial review process. They are considered very important, but of lower priority than the high-priority issues. They are lower priority because research projects are currently addressing these issues, or because the issue is not understood to be of great urgency in California at this time. These issues will be reevaluated at the next review period to assess the results of ongoing research and the degree of urgency in the State.

1. There is a need for improved methods, tools and data to develop practical interpollutant, interbasin, and intercredit offset rules.
2. Compliance with future global climate change initiatives (e.g., Kyoto Protocol or its derivatives) is more difficult because of possible greater use of fossil-fueled facilities and greenhouse gas (GHG) emissions. There is a need for improved methods and analytical instruments to estimate the potential State-level impact of various national and international schemes that are being proposed to reduce GHG emissions. This includes impacts on the price of electricity and the overall price and demand of energy. Significant changes in energy prices may have a significant impact on California's economy.
3. Hydroelectric power generation changes the historic sediment loading in streams and accumulation behind dams, and can drastically alter normal sediment transfer for all points downstream.
4. Possible greater weather variability (more frequent and extreme El Niño events, droughts, and floods) may affect land-use patterns and decisions that will impact operations and costs of the generation, transmission, and distribution systems. Power plants in the coastal areas may be affected by sea-level rise. The amount of generation of power in hydroelectric facilities may be severely affected by the timing of precipitation, the form of this precipitation (snow or wet rain), and the total amount of water delivered by precipitation.
5. Increased demand for water and concerns about water supply require power plants to identify opportunities for and implement greater water use efficiencies.
6. Market-based approaches to water allocation need to be explored to reflect the increasing movement toward water transfers, the need to place a value on non-market beneficial uses of water, and the increased competition for water, and to address existing flawed incentives.
7. Greater use of biomass fuels may be promoted (e.g., gas from landfills and sewage systems, fuels from crop and timber residues, and dedicated annual crops, tree farms, or aquaculture systems) as a mitigation measure for global climate change, but the environmental impacts of greater use of biomass fuels must be determined.
8. There is a need for improved methods, tools and data for: (1) performing adequate construction impact analyses[1]; (2) quantifying emissions during start-up and shutdown conditions (the highest impacts from new facilities are estimated to occur during these transient conditions); (3) estimating short-range air quality impacts; (4) quantifying emissions during commissioning[2]; and (5) the selection of Best Available Control Technology (BACT) for certain emissions.

[1] This type of analysis would include the analysis of fugitive dust and emissions from transportation vehicles (e.g., diesel from bulldozers) used in constructing the power plant.

[2] Commissioning is the period that starts after the first firing of a combustion system in a new power plant and ends with culmination of the testing and fine tuning of the combustion and control systems. Emissions during commissioning are both high and transient, making measurement difficult.

9. There is a need for improved methods, tools and data to address multiple and cumulative environmental impacts from multiple energy suppliers.
10. Water quality standards for water supply and wastewater treatment may require energy-intensive processes.
11. Water conservation standards and stringent water quality discharge standards, to address such impacts as elevated levels of inorganic (e.g. metals) compounds, can increase the cost of operating power plants.
12. The level of effectiveness of past environmental mitigation measures applied to electricity generation, transmission, and distribution needs to be assessed to quantify and verify that measures are meeting intended goals and outcomes.
13. Increased air emissions from power plants will lead to increased atmospheric deposition that can contribute to degradation of water quality and terrestrial ecosystems.
14. There is a need for improved methods, tools and data to accurately measure PM and NO_X emissions as they relate to the generation, transmission, distribution, and use of electricity.
15. There is a need for improved methods, tools and data to evaluate the impact of power plant plumes on ozone and secondary particulate matter.
16. Spills from transformers and leaching of wood preservative compounds from transmission line poles may contaminate both land and water.
17. Managing vegetation under major power lines, such as clearing of vegetation and the use of herbicides, could result in significant environmental impacts to aquatic and terrestrial ecosystems.
18. The effect of electric and magnetic fields on biological systems continues to be controversial.
19. The disposal of wastes from nuclear power plants and the decommissioning of nuclear facilities continues to be controversial.

Appendix C
Evaluation Criteria

Appendix C

FORM FOR EVALUATING ENVIRONMENTAL ISSUES

Issue: _____ (abbreviation) **Reviewer: _____ (initials)** **First-year funding? _____**

Criteria	Measurement Scale	Score	Comments
Degree of urgency for resolving the issue	The issue is of: (1) low degree of urgency (e.g. addresses improvement of important but functioning regulatory processes); (2) moderate degree of urgency (e.g., addresses an ongoing and significant environmental impact); (3) high degree of urgency (e.g. addresses pressing impact on public health or safety).		
Statewide significance of the issue – Part 1	The issue is: (1) site-specific; (2) regional; (3) significant throughout State.		
Statewide significance of the issue – Part 2	The issue is (1) national in scope; (2) national but of particular importance in State; (3) State-specific.		
Issue is being addressed by other R&D institutions	The issue is: (1) substantially addressed by other institutions; (2) partially addressed by other institutions; (3) not addressed by other institutions.		
Issue addresses the need to improve the <u>understanding</u> of environmental impacts	The issue addresses: (1) possible impacts of unknown significance; (2) possible but significant impacts; (3) significant and documented impacts.		

Issue addresses documented electricity-related scientific needs for improving policy-making & decision-making [Strategic importance] [gaps]	The issue addresses: (1) somewhat important scientific needs; (2) very important scientific needs; (3) urgent scientific needs for decision-making.		
Issue addresses mitigation needs of electricity-related environmental impacts	The issue addresses: (1) somewhat important mitigation needs; (2) very important mitigation needs; (3) urgent mitigation needs.		
Estimated cost of research addressing issue	Addressing this issue will cost: (1) < $100,000; (2) $100,000 - $1,000,000 ; (3) > $1,000,000		
Potential cost-sharing by other organizations	(1) low; (2) medium; (3) high		
Probability that innovative solutions will be successfully developed to address this issue	(1) 1-33%; (2) 34-66%; (3) 67-100%		
Probability that innovative solutions will be successfully implemented (once developed) to address this issue	(1) 1-33%; (2) 34-66%; (3) 67-100%		
Probability that innovative solutions will be accepted in the California market (once developed and implemented) to address this issue	(1) 1-33%; (2) 34-66%; (3) 67-100%		
Issue addresses more than one subject area	The issue has implications for: (1) one subject area; (2) two subject areas; (3) three or more subject areas.		

Criteria	Implications*	Magnitude of Impact**	Score	Comments
Issue addresses sensitive or endangered species	(1) no implications; (2) slight implications; (3) significant implications.	(1) impacts of unknown significance; (2) significant but not documented impacts; (3) significant and well documented impacts		
Issue addresses habitat concerns	(1) no implications; (2) slight implications; (3) significant implications.	(1) impacts of unknown significance; (2) significant but not documented impacts; (3) significant and well documented impacts		
Issue addresses California's biodiversity (ecological health)	(1) no implications; (2) slight implications; (3) significant implications.	(1) impacts of unknown significance; (2) significant but not documented impacts; (3) significant and well documented impacts		
Issue addresses California's ecosystem services***	(1) no implications; (2) slight implications; (3) significant implications.	(1) impacts of unknown significance; (2) significant but not documented impacts; (3) significant and well documented impacts		
Issue addresses public health and safety	(1) no implications; (2) slight implications; (3) significant implications.	(1) impacts of unknown significance; (2) significant but not documented impacts; (3) significant and well documented impacts		
Issue addresses recreational concerns	(1) no implications; (2) slight implications; (3) significant implications.	(1) impacts of unknown significance; (2) significant but not documented impacts; (3) significant and well documented impacts		

Issue addresses resource consumption (habitat, fresh water, materials, etc.)	(1) no implications; (2) slight implications; (3) significant implications.	(1) impacts of unknown significance; (2) significant but not documented impacts; (3) significant and well documented impacts		
Issue addresses energy costs	(1) no implications; (2) slight implications; (3) significant implications.	(1) impacts of unknown significance; (2) significant but not documented impacts; (3) significant and well documented impacts		
Issue addresses system reliability	(1) no implications; (2) slight implications; (3) significant implications.	(1) impacts of unknown significance; (2) significant but not documented impacts; (3) significant and well documented impacts		
Issue addresses sustainability of California's electricity system and environment	(1) no implications; (2) slight implications; (3) significant implications.	(1) impacts of unknown significance; (2) significant but not documented impacts; (3) significant and well documented impacts		

* For example: the issue has: (1) no implications for affecting sensitive or endangered species; (2) slight implications for affecting sensitive or endangered species; (3) great implications for affecting sensitive or endangered species.

** For example, the issue addresses endangered or sensitive species impacts of: (1) unknown significance; (2) significance but not documented; (3) significance and well documented.

*** Ecosystem services represent benefits to human populations that are derived from healthy ecosystem functions. These benefits include market values (e.g., commercial fisheries or timber market) and non-market values that contribute to human welfare (e.g., recreation, conservation, and spiritual

Appendix D
Stakeholder Review Group

PIER Environmental Area Stakeholder Review Group

Association of California Water Agencies	Dan Smith
Biomass Energy Alliance	Bob Judd
California Air Resources Board	Bart Croes
California Department of Fish and Game	Sandy Morey
California Department of Water Resources	Barbara McDonnell
California Environmental Protection Agency	Bill Vance
California Farm Bureau	Karen Mills
California Independent System Operator	Dave Hawkins
California Manufacturers and Technologies Association	Dorothy Rodrock
California Resources Agency	Cathy Bleier
California Solar Energy Industries Association	Les Nelson
California Wind Energy Association	Nancy Rader
Center for Energy Efficiency and Renewable Technologies	Rich Ferguson
Environmental Defense	Dan Kirshner
Geothermal Energy Association	Karl Gawell
Green Mountain Energy	Rich Counihan
Independent Energy Producers	Steve Kelley
Natural Resources Defense Council	Sheryl Carter
Pacific Gas and Electric Company	Steven McCarty
Pacific Institute for Studies in Development, Environment, and Security	Peter Gleick
Resource Catalysts	Shirley Rivera
Sacramento Municipal Utility District	Bud Beebe
Silicon Valley Manufacturing Group	Justin Bradley
Southern California Edison Company	Gene Rodrigues
Southern California Gas Company	Mark Gaines
State Water Resources Control Board	Tom Howard
Union of Concerned Scientists	Julia Levin
U.S. Environmental Protection Agency (Region IX)	Matt Haber
U.S. Fish & Wildlife Service	Dale Pierce

Appendix E
Highlights of the Review of the Draft CEC Staff Report

Appendix E

Highlights of the Review of the Draft CEC Staff Report "PIER Environmental Area Research Plan: Environmental Context and Key Environmental Issues"

The draft Energy Commission staff report, "PIER Environmental Area Research Plan: Environmental Context and Key Environmental Issues," was distributed to all 29 members of the Stakeholder Review Group (SRG) that was established by the Energy Commission CEC to provide assistance to the PIER Environmental Area (PIEREA) planning process. In addition, the report was sent to 110 technical reviewers. Responses were received from 21 members of the SRG (164 comments, 73 pages) and 45 technical reviewers (218 comments, 78 pages). The Energy Commission was very pleased with the response rate from these individuals, because the report had been distributed during the winter holidays and during a time when many of these reviewers were directly involved in policy-level discussions (in California and Washington, D.C.) regarding California's energy situation. The quality of the review comments were informative, constructive, and focused. The comments will be useful not only for preparing the final report, but also for developing more detailed research plans (roadmaps) for each of the high-priority environmental issues described in the report.

In general, the review comments were very positive. Most reviewers felt that the draft report represented an excellent first step in addressing the key environmental issues that the PIEREA Program should target. Several reviewers indicated that this was the first time that they had seen a report that systematically and comprehensively addressed environmental issues related to the generation, transmission, and distribution, and use of electricity. Consequently, most review comments offered editorial changes, clarifications, and additional information that should be included in the report.

California Energy Commission staff and the project's Core Team met on January 19, 2001 to discuss the reviewers' comments. Energy Commission staff and the Core Team later reviewed these comments in detail and provided suggestions for addressing these comments for the draft report revision. Based on the comments and discussions, the following major changes were made to the draft report:

- The high-priority issue, "Air Quality Benefits and Impacts of Renewable Energy Technologies," located in the Air Quality section, was moved to the Crosscutting section. The title was revised and the description of this issue was expanded to include a more comprehensive analysis of renewable energy technologies (including biomass). Additional topics were included: fuel-cycle analysis of renewable energy technologies (environmental life-cycle assessment) and cumulative, multimedia impacts (e.g., air, water, and land use).

- The title of the high-priority issue, "Air Quality Impacts of Energy-Efficiency Measures," was revised to say "Air Quality Impacts of Energy-Efficiency and Load Management Measures" to reflect the recent, increased interest in the State on load management measures.
- A small section was added to explain why certain issues were not addressed in the report (e.g., issues were being addressed by current Energy Commission projects or by other agencies).
- A small section was added to the report to explain how high-priority issues were selected.

Finally, as mentioned previously, many reviewers suggested ideas for excellent research projects that the Energy Commission should consider for funding. These ideas will be considered during the roadmapping exercise, where more detailed research plans for the high-priority environmental issues are being developed. It is expected that the SRG and technical reviewers will review the draft Roadmaps, once they have been completed.